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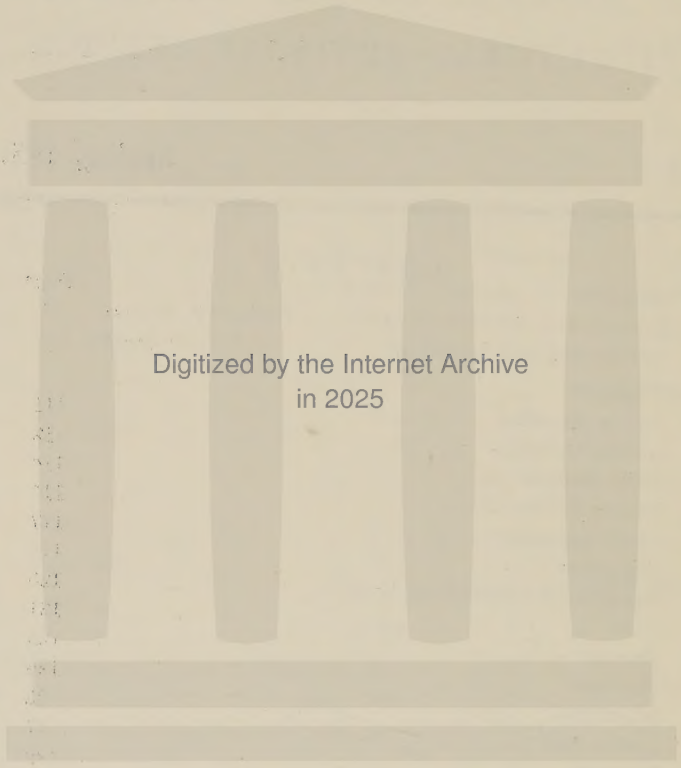

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ARTICLES

THE MINERAL NUTRITION OF CROPS

SOME RECENT DEVELOPMENTS IN RESEARCH

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Research work over many years has demonstrated the large number of elements that may occur in plants other than those usually recognized in considering the nutrient requirements of crops. It has also been shown that many plants may accumulate large amounts of these unusual elements[1], such as hickory-aluminium, *Astragalus* sp.-selenium, Brazil nut-barium. The late Professor Nemec[2] reported the accumulation of gold in *Equisetum palustri* growing on certain soils in Bohemia and the presence of droplets of metallic mercury in the seed capsules of *Holosteum umbellatum.* Such findings naturally raise the question whether these various elements are essential for plant growth or whether the presence of many of them is merely fortuitous.

In the present state of knowledge it is usual to classify the mineral elements in plants, as regards their nutrient properties, into three groups : essential elements, beneficial elements and other elements.

The essential elements are those that have been proved to be necessary for the healthy growth of plants. They are twelve in number and are subdivided into two groups, each consisting of six elements, viz., major elements, needed in relatively large amounts by plants (nitrogen, phosphorus, calcium, magnesium, potassium and sulphur), and minor, trace or micro-nutrient elements, required only in relatively small quantities (iron, manganese, boron, copper, zinc and molybdenum).

Criteria of the essentiality of an element have been suggested by Arnon[3] as follows :

1. The life cycle of the plant cannot be completed if the element is omitted.
2. The action of the element must be specific.
3. The effect on the plant must be direct.

The carrying out of tests to establish these criteria for further elements to be added to the present list is likely to be very difficult, as will be judged from the fact that, in proving the essential nature of molybdenum for tomato, Arnon and Stout[4] obtained healthy plants with a nutrient solution containing 0.01 p.p.m. molybdenum. In recent sand culture experiments at Long Ashton, Hewitt has been investigating the problems of the molybdenum nutrition of cauliflower, using solutions ranging from a lower limit of 0.000005 p.p.m. of the element. Thus the lower limits necessary to prove essentiality of further elements are probably incapable of achievement within the refinements in techniques possible at present. In spite of this, the present list of essential elements should not be regarded as final. It is also an interest-

ing fact that, notwithstanding the great refinements necessary to prove the essential nature of trace elements, deficiencies of them, even to the extent of causing total failures, are widespread in soils the world over.

Beneficial elements may be defined as those elements which produce beneficial effects on the growth of plants, such as yield increases, but without which the plants can complete their life cycles. The beneficial effects of elements in this group are generally obvious only for special groups of plants, such as sodium for the sugar beet family, but the effects are nevertheless of great importance in agriculture[5]. In addition to sodium, silicon, chlorine and aluminium have been regarded as producing beneficial effects.

Some of the heavy metals are of interest in considering beneficial effects. Thus nickel and cobalt are highly toxic to plants even at very low concentrations, yet Roach[6] has reported substantial yield increases with nickel for crops in Romney Marsh and, in view of the importance of cobalt for animals, this element also might be expected to play some useful role in plant nutrition, but this has never been demonstrated.

Elements of the third group, " other elements," may be either without observable effect on growth or they may be highly toxic, and here it is of interest that, whilst plants show selective action with regard to the intake of the proportions of nutrients, they do not possess mechanisms for excluding toxic amounts of harmful elements. Here again, plants show large differences in regard to resistance to injury. In an experiment at Long Ashton[7] with various fruits growing together on special plots receiving kainit and muriate of potash treatments, red currants were severely injured, gooseberries, raspberries and strawberries showed some injury, and apples and black currants showed no signs of damage. Analysis of the leaves of the treated plants gave chloride contents in accordance with the observed effects.

The Mineral Status of Crops

The main problems that arise in connection with the mineral status of crops concern deficiencies, excesses and inter-relationships of the nutrient elements. The subject of inter-relationships is often also referred to as nutrient balance or interaction of nutrients.

The problems in crops may concern both yields and quality aspects, the latter being of importance in many problems of animal and human nutrition, and in cases where special food crops, such as fruit, must conform to the special requirements of the consumer.

Goodall and Gregory[8] have defined a mineral deficiency in relation to yield as follows : *A plant is deficient in a certain element if supplying that element to the plant in a suitable form causes an increase in yield, this effect being specific for the element in question.* This definition can be extended to define an excess, i.e., when the element either produces no further increase or leads to a decrease in yield.

It has been shown that the yield curves obtained when deficient

elements are added usually approximate to a straight line or to a hyperbola, in accordance with Mitscherlich's law of diminishing returns, but that these curves may be altered to the sigmoid form where interactions occur, particularly when elements exercise antagonistic effects and are present in widely differing amounts.

Samples of yield curves are well illustrated in the extensive experiments of Lundegårdh [9, 10, 11].

Purely from the point of view of plant nutrition, deficiencies may be regarded in another way. Thus, a deficiency may be said to exist when the amount of any given nutrient in the various organs of the plant is insufficient for the proper functioning of these to produce vegetative growth, flowers and fruits. These critical levels are those below which the so-called " deficiency symptoms " are in evidence, sometimes so strikingly as to be termed " deficiency diseases ". It must be realized, however, that, in practice, nutrient elements may continue to increase yields well above the critical levels for minimum functioning. The foliar diagnostic methods that relate yields to chemical composition of the foliage are based on this latter conception and aim at indicating conditions giving optimal yields.

The main effects produced by deficiencies of each of the twelve essential elements are now well established and descriptions are available from many sources in the literature [12]. In England those that are less likely to be known are sulphur, copper, zinc and molybdenum. Sulphur deficiency has not yet been reported in Great Britain and is unlikely to be important in view of the highly industrialized nature of the country, as such conditions have been shown to supply enough sulphur to soils and plant foliage to preclude deficiency conditions. Sulphur is, of course, also widely used in common fertilizers.

Deficiencies of copper, zinc and molybdenum have only recently been proved in crops in England [13, 14, 15, 16, 17] and typical examples of the symptoms are shown in the art inset. It may be noted that symptoms of copper deficiency usually take the form of die-back of young vegetative growths, as, for example in oats, in which crop it is termed " Wither tip " (also reclamation disease) and in apple trees, when it is known as " Summer die-back ". A common feature of zinc deficiency is stunting and rosetting of shoots due to short internodes and small narrow leaves—" little leaf " condition. Mottling may also occur, as in citrus " mottle leaf."

Molybdenum deficiency effects in this country have so far been seen only in brassica crops (cauliflower, broccoli, Brussels sprouts and Savoys) in which crops the deficiency results in distortion and strap-like effects in the younger leaves, e.g., whiptail of cauliflower and broccoli. In legumes, the deficiency may be expressed as nitrogen deficiency, since the nitrogen-fixing powers of the nodule organisms are greatly reduced and the organisms suffer from the deficiency before the plants themselves. Deficiency effects have been produced in a wide range of agricultural and horticultural crops at Long Ashton by Dr. Hewitt[18], common leaf symptoms being a mottled chlorosis and a papery effect of the margins prior to the reduction of the lamina.

Two possible effects may result from excesses of mineral nutrients. The plants may simply absorb more than they need for maximum growth, without harmful effects, or they may suffer severe injury. The former condition is usually referred to as "luxury consumption" and may be important either in providing desired high levels of minerals for stock or in leading to harmful excesses in crops, such as occur in the teart pastures in Somerset where molybdenum is absorbed in luxury amounts[19]. Where damage occurs to a plant from an excess, it may be due to direct injury, or the injury may be indirect by affecting the intake or functioning of another nutrient, i.e., antagonism.

Nutrient Balance and Interactions

Recent research on the status and functions of mineral nutrients has stressed the importance of the inter-relationships between the various elements[20]. Thus, it is not only important that plants should be supplied with all the essential elements, but that the elements should be present in the plants in fairly well defined proportions. The reason for this is that the various nutrients enter into complex interactions and, in these, some of them tend to oppose one another (antagonism) and others to be mutually beneficial (synergism). These reactions occur both in the soil, affecting absorption, and in the plant organs, affecting metabolic processes. The antagonistic effects are most pronounced when the reacting elements are present in widely differing amounts [11, 21].

A knowledge of the relationships between the various elements and the seat of the reactions between them are of importance in practice, as may be instanced by the antagonistic effects of K/Mg and Zn/Fe. In the former instance, it is common experience with crops such as tomatoes and apples, that very heavy soil dressings of magnesium are necessary to correct a deficiency of the element, whereas much smaller amounts will suffice when the element is applied as a foliage spray[22]. Here, there is an important effect in the soil affecting absorption. In the latter, there is a clear effect of the excess of zinc within the plant, for even if iron is applied via the leaves, the beneficial effect is only temporary and the iron deficiency cannot be remedied[23]. Interesting examples of synergistic effects are provided by N/Mg and K/Fe, in both cases the first element producing beneficial effects on the second (see page iii of the art inset).

The effect of nitrogen on magnesium status is very important in practice, as has been shown for tomatoes, potatoes, brassica crops and fruit, whilst it is of interest that deficiencies of iron and potassium commonly occur together on calcareous soils.

Some examples of antagonisms and synergisms that have been shown in experiments are as follows :

Antagonisms: N/P ; N/K ; K/Mg ; Mg/K ; P/K ; N/Ca ; Na/Ca ; K/Ca ; Mg/Ca ; Ca/Mn ; K/Mn ; Mn, Cu, Zn, Cr, Co, Ni/Fe.

Beneficial effects: N/Mg ; K/Fe.

Soil Factors Affecting the Supply of Mineral Nutrients to Plants

The supply of mineral nutrients in soils is affected by many factors of which the following may be selected for their importance and in illustration of the complexity of the problems involved :

1. The fixing power of soils for nutrients.
2. Soil reaction (*p*H).
3. Organic matter, drainage conditions and aeration.

Fixing power of soils. The colloidal nature of the clay and humus fractions of soils, which is responsible for their well known properties of adsorption, is now well recognized and the differing crystal lattice structures of the various types of clay are also well known to soil scientists. These characters are of prime importance in determining the availability of mineral nutrients to plants.

It is now possible to explain many phenomena relating to the availability of the basic nutrients, furnishing kations, on conceptions of " base exchange", together with some special reactions in the crystal lattice[24]. Similarly recent researches have indicated the importance of adsorption phenomena in determining the fixation of phosphates both in calcareous and acid soils[24, 25].

The recognition of the magnitude of these adsorption effects in the practical use of fertilizers has led to numerous experiments on fertilizer placement methods, and comparisons of different forms of fertilizers, with different physical and chemical properties, in an endeavour to minimize these fixation effects. In these experiments, phosphates have attracted most attention[26, 27], but potassic and nitrogenous fertilizers have also been examined. The experiments of the Rothamsted workers with phosphates on cereals and of Nicholson with potash on barley on chalk soils, illustrate well the differences that may result in comparisons between fertilizers broadcast and placed with the seed. In the phosphate experiments 1½ cwt. of superphosphate placed was as effective as 3 cwt. broadcast, and on poor chalk soils ½ cwt. muriate of potash placed was as effective or better than 2 cwt. broadcast. So far, no advantage of placement over broadcasting nitrogenous fertilizers has been shown.

Åslander[28], in Sweden, has attempted to overcome phosphate fixation on acid soils by mixing the fertilizer thoroughly with dung. He claims by this method to obtain better results than by correcting the acidity with lime prior to phosphate application in the usual way.

It must also be recognized that, in addition to fixation by physio-chemical adsorption, biological fixation may be of great importance in some soils and may even bring about deficiency conditions, as can be readily demonstrated for nitrogen and as is believed to occur for manganese, copper and zinc[29, 30, 31].

Soil reaction. The *p*H of soils determines, in great measure, the supplies of soil nutrients and their availability to plants.

Thus, strongly acid soils contain relatively low amounts of the basic nutrients, calcium, potassium and magnesium, and the availability of nitrogen and phosphorus is low. Trace elements, with the exception of

molybdenum, tend to increase with acidity and, under strongly acid conditions lasting for long periods, may undergo considerable leaching, though they are readily available so long as supplies last. Acid soils usually contain excessive amounts of soluble manganese and aluminium and sometimes also of iron, whilst the concentration of hydrogen ions present is also high[32] and each of these factors may be responsible for failures in crops. In some acid soils, however, crops may suffer from a deficiency of iron, where other trace elements, particularly manganese, copper or zinc are abnormally high. Oats appear to be readily affected under such conditions.

On the other hand, soils of high *p*H, where this is due to calcium carbonate, are characterized by a high calcium status, and the conditions are generally favourable for high availability of nitrogen and phosphorus. Supplies of magnesium and potassium are variable according to the nature of the parent rock. The availability of the trace elements, with the exception of molybdenum, is low and, where total supplies have been previously depleted under acid conditions, the raising of the *p*H by liming may induce acute deficiencies of them. The prevalence of boron deficiency in the podsolic soil areas of the U.S.A. and in Finnish soils, is considered to be due to such a sequence of events. In alkali soils, sodium is the dominant kation and calcium may be relatively low, with resultant deficiencies in crops of the latter element.

Truog has produced an informative diagram illustrating the effect of *p*H over a wide range on the availability of all the nutrient elements with the exception of molybdenum[33]. If it is remembered in connection with this diagram that molybdenum availability increases steadily with rise in *p*H, a useful picture of *p*H effect for all the essential elements can be readily obtained.

Organic matter, drainage conditions and aeration. These three factors are of importance in regulating the availability of nutrients in the soil, and also affect the absorbing properties of root systems.

Organic matter produces large effects on soil structure and also largely determines the nature and numbers of the soil organisms. Its adsorptive properties have already been mentioned. As regards its effects on the availability of individual nutrients to plants, it may increase the availability of iron [34] and may decrease the availability of manganese, copper and zinc, possibly through the action of the organisms it supports. The effects of the carbohydrate fractions of the organic matter on the availability of nitrogen are well known and require no emphasis here.

Drainage affects both the water content of the soil and the complementary soil atmosphere, and hence drainage and aeration may be considered together. The soil water directly affects the supply of nutrients by its solvent action and its movement through the soil, but its effects on aeration are also important as it determines whether or not conditions will be aerobic or anaerobic. Under aerobic conditions, the oxygen supply is high and this condition favours the efficient root action and absorptive powers of the large majority of crops. Certain elements, however, may have a relatively low availability under aerobic

conditions, e.g., manganese [35, 36], as they favour the formation of more highly oxidized compounds of the element. In waterlogged soils, where anaerobic conditions exist, the oxygen supply may be inadequate for the proper functioning of the plant roots and harmful effects may arise from high concentrations of carbon dioxide.

Waterlogged conditions favour high solubility of manganese and iron but they produce deleterious effects on the absorption of other elements, notably potassium, nitrogen, phosphorus, calcium and magnesium[37].

For this reason disappointing results may be obtained in attempting to correct nutrient deficiencies on poorly drained soils.

Methods of Assessing the Nutrient Requirements of Crops

The methods used to determine the nutrient requirements of crops on any given site fall into three groups covering the examination of soil or plant characters and field experiments with fertilizers. As the special features of many of these are widely utilized by officers of the N.A.A.S., it will be necessary in the present article to refer only to the more recent developments and viewpoints.

In the first place, it must be emphasized that even the more recent methods are largely empirical and are not infallible, and it is only by using combinations of the various methods, coupled with field experience, that sound conclusions from the data are likely to be drawn.

During the last decade or two, much more emphasis has been laid on the use of methods based on the plants, including visual characters, the composition of plant parts and the reaction of the plants to foliage sprays and injections. Some of these procedures are mainly qualitative in character and at best give only approximate quantitative data. More recently, several workers have attempted to relate the chemical data from plants with yield data, and considerable success has been achieved in this way, notably by Lundegårdh in Sweden[9, 10, 11] and Craig and Halais [38] in Mauritius, whilst in this country Goodall [39, 40] has carried out preliminary experiments with potash and manganese on cereals, as has also Nicholas[41] with the latter. The work is a natural extension of the method of foliar diagnosis first developed in France by Lagatu and Maume[42] and later in the U.S.A. by Thomas[43]. Lundegårdh's work[9, 10, 11] is of particular interest in this country, as he has attempted to apply the method to cereal crops, whilst Halais[44] has demonstrated the special applicability of the method to a single crop like sugar cane which is admirably suited because of its vegetative character.

Goodall and Gregory[8] have also suggested the application of the foliar diagnostic technique to determine critical points in growth, such as, for example, the amount of any given nutrient necessary for grain formation in any particular cereal. They believe also that critical values for various cereals can be related to maximum yields of grain. If this is so, and typical curves relating chemical status to yields can

be obtained, the method will add considerably to the precision of methods now in use. Lundegårdh, in attempting to apply a similar conception, has shown that the usual curves (of the Mitscherlich type) may be modified by certain factors and has suggested his " triple analysis method " to meet certain of the difficulties[10].

Bray[45] in the U.S.A., has developed a similar method relating soil data to yields and has applied it with success to maize.

A further extension of these methods, which is receiving attention at Long Ashton, is the use of quick chemical tests[46] to provide the chemical data and thus to speed up the laboratory procedures.

Another point of interest that continues to attract attention is that of methods of determining the availability of trace elements in soils, particularly iron, manganese, copper, zinc and, more recently, molybdenum [30, 35, 36, 47, 48, 49, 50]. Methods proposed for boron seem to be fairly satisfactory[51]. Manganese, in particular, has received much attention and has provided very difficult problems owing to the action of organisms and oxidation/reduction phenomena. Copper and zinc also present complications due to the action of organisms. Recently, Mulder[52] in Holland has used a special strain of *Aspergillus niger* to assess the magnesium, copper and molybdenum status of soils, and Nicholas[53, 54] has developed techniques, using Mulder's strain, for magnesium, manganese, copper, zinc and molybdenum, and has applied them with success to field problems. At the present time, it seems that the *Aspergillus* method is by far the best method, if, indeed, not the only reliable one, for trace elements (anomolous results have been reported for the Aspergillus method on peat soils in New Zealand), with the exception of boron, which element is not essential for the nutrition of the fungus. The main drawback to the wide use of the method is its exacting nature. Attempts are also being made to apply the method to iron, for which no reliable chemical method, using either soil or plants, exists.

It can, however, be fairly stated that at present it is possible to diagnose by a suitable choice of the methods available the status of any of the known nutrient elements.

Methods of Applying Mineral Nutrients

In concluding this account, it will be useful to list the various methods by which nutrient elements may be effectively applied to crops, since a knowledge of them and their special application to the varied problems of nutrient status is of immense value.

The main methods are as follows :

1. Ploughing-in of bulky manures.
2. Placing of bulky manures in furrows, e.g., for potatoes.
3. Surface mulching with bulky manures.
4. Broadcasting of fertilizers.
5. Placing of fertilizers near the seed, as in combine drills.
6. Furrow and other deep soil application methods for fertilizers.
7. Surface soil applications of fertilizer solutions (liquid fertilizers).
8. Power injection of fertilizer solutions into subsoils for deep rooted plants (e.g., fruit trees).

9. Application of fertilizer solutions to seedlings, in boxes or on planting out (starter solutions).
10. Application of very dilute fertilizer solutions in irrigation water applied from overhead mains.
11. Use of foliage sprays and dusts.
12. Seed soaking with nutrients or seed dusting prior to sowing.
13. Injection of solid nutrient salts into woody stems, for tree crops.
14. Green manuring.
15. Permanent cover crops, with and without mulches, for fruit trees.

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Your Weather Service, referred to in Mr. L. P. Smith's article opposite, will be of interest to readers.

For a small fee, any person may obtain a personal forecast for his local district or town, covering a period of 24 hours from the time of issue.

The booklet describes the special services provided for farmers and contains an interesting section on how to interpret weather forecasts — what exactly is the difference between "fair" and "fine", "showers" and "occasional rain", "fog" and "mist", "strong wind" and "gale". It is available from H.M. Stationery Office, price 1s. (1s. 2d. by post).

METEOROLOGY AND AGRICULTURE

L. P. Smith
Meteorological Office

The duty of the members of the Agricultural Branch of the Meteorological Office (M.O.19) is to act as liaison officers between meteorologists and agriculturists. Their aim is to ensure the maximum application of meteorological knowledge, facilities and data to the solving of agricultural problems, and, furthermore, to improve such knowledge and facilities wherever possible. Their numbers are at present small, consisting of two sections only. The Agricultural Branch headquarters, under the writer, is situated at Harrow ; one officer, Mr. R. W. Gloyne, is stationed at the N.A.A.S. Provincial headquarters at Bristol. In the course of their work they meet many specialists and advisory officers not only within the N.A.A.S., but also at universities, research stations and experimental farms. With the limited staff available such personal contact is not possible in every case, so that this article aims at explaining the type of help that the Meteorological Office can offer.

Forecasts of Weather

For an efficient forecast service, certain essential conditions must be fulfilled :

(*a*) A forecast must be prepared for a given place. Except during settled fine weather or widespread rain, the weather over Britain varies considerably over short distances. Many of these local variations are well-known and can be predicted. For this reason alone, a general forecast loses in accuracy unless it is of inordinate length.

(*b*) A forecast must be prepared for a given purpose. Different weather requirements demand that forecasts must stress different weather elements and different critical values.

A wind of 35 m.p.h. across a runway might seriously affect the landing of an aircraft ; a wind of 25 m.p.h. might trouble a yachtsman ; a wind exceeding 15 m.p.h. might render certain types of spraying a difficult procedure.

(*c*) A forecast must reach the recipient with as little time lag as possible. The shorter the forecast range, the more accurate is the forecast. If, therefore, a long time elapses between the issue and receipt of a forecast, then it is the most accurate part of the forecast which is being nullified.

(*d*) A forecast must be regarded only as the most probable future weather. The best type of forecast should indicate not only the most probable weather, but also the degree of probability and, more important still, the possible alternatives.

If we now assess the existing forecast facilities in the light of these criteria, we see immediately that a forecast in a newspaper is of very limited use. There is a long time lag between time of issue and publication, the areas referred to are large, and the forecast has to be given in

very general terms for a variety of purposes. With regard to the B.B.C. forecast bulletins, the time lag between issue and reception is much shorter, but the time available for reading the forecast is such that it does not permit of a description of the weather in the necessary detail. It is almost impossible to give an accurate description of the *existing* weather over Britain and the surrounding seas in as short a time as five minutes, still less can sufficient detail be given for the *expected* weather over the following 24 or 36 hours.

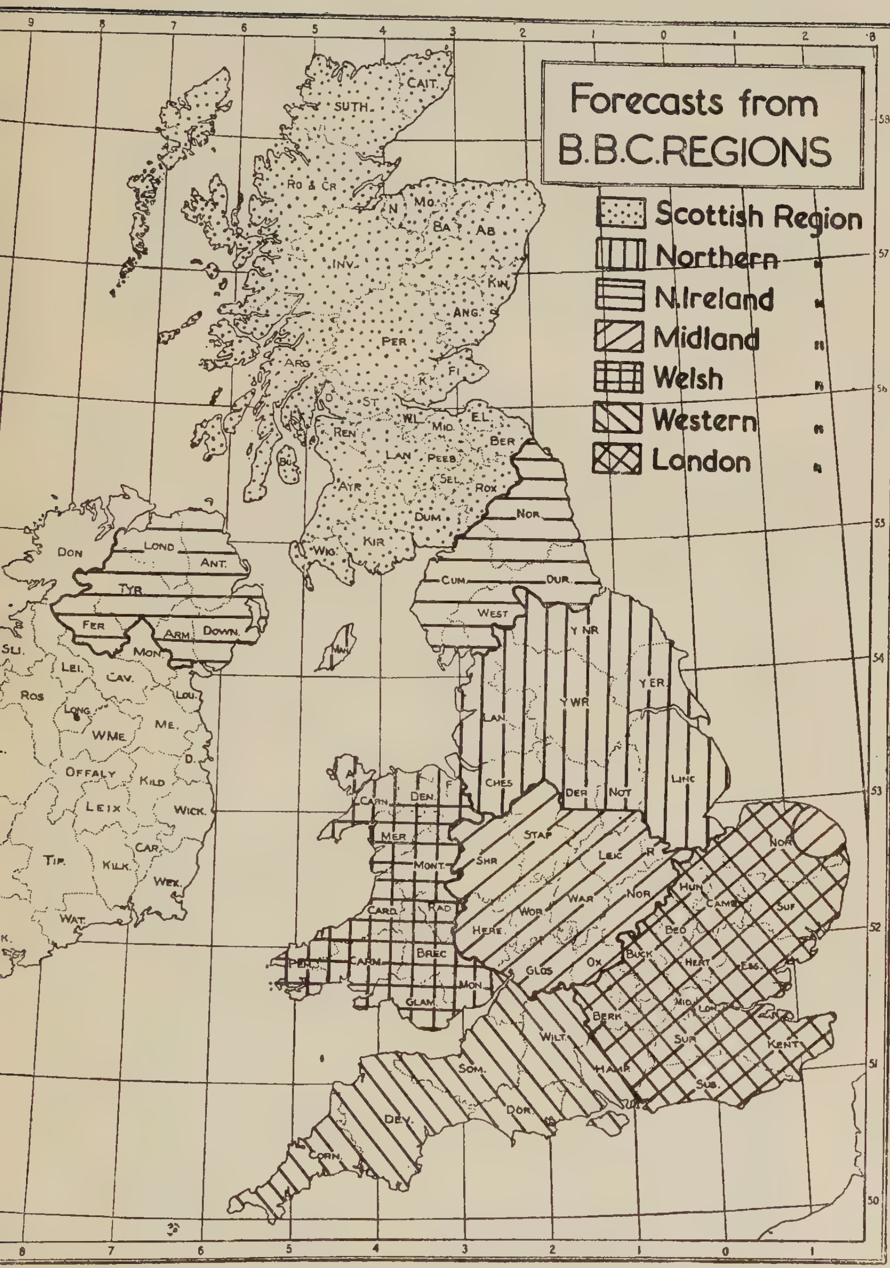
This difficulty is fully realized by the Meteorological Office. In order partially to overcome this, a new arrangement has recently been made with the B.B.C. whereby at 5.55 p.m. the forecast bulletin contains gale warnings, shipping forecasts, general inference, general forecast and further outlook, followed by *one* regional forecast only, namely, the one appropriate to the transmitter from which it is sent. This means that the regional or district forecast is now four or five times longer than hitherto, and that much more of the necessary detail can be included. The map reproduced on page 105 shows the areas which are covered by these regional forecasts. It will be noticed that a small area of East Norfolk is included in the Midland Regional forecast; this is due to the existence of a transmitter at Norwich working on the Midland wavelength. The four northern counties of England are at present covered by forecasts issued both from Belfast and Manchester, but it is understood that the former transmitter provides the best reception over most of this area.

Despite the obvious advantages in this new arrangement, we must look further for a precise guide sufficient to meet specific farming needs within the limit of the skill of modern forecasting. It is not generally known that there are some 17 meteorological stations in England and Scotland to which telephone calls can be made by members of the public for the purpose of obtaining weather forecasts for the next 24 hours. These are known as " Post Office Guide Stations " because full details of this service are contained in this publication. A map showing the position of these stations and their telephone numbers is shown on page 107. Any farmer or grower who is near such a station can speak by telephone to the duty forecaster and explain precisely what type of forecast he requires; he will obtain the best available information covering the next 24 hours. No charge is made for this service.

Special forecasts, such as the notification of expected dry spells, can be obtained from the Central Forecasting Office at Dunstable on the payment of a small charge. Full details of such services are contained in Form 2453, which can be obtained from the Meteorological Office, and also in a booklet entitled *Your Weather Service.**

Arrangements have also recently been made for the issue of forecasts of frosts in spring and autumn, and of snow during winter, through the co-operation of the county secretaries of the National Farmers' Union. The underlying principle is that farmers who hear a general warning

* Obtainable from H.M. Stationery Office, or through any bookseller, price 1s. (1s. 2d. by post).


Forecasts from
B.B.C. REGIONS
Scottish Region
Northern
N. Ireland
Midland
Welsh
Western
London

of this nature on, say, the one o'clock B.B.C. bulletin, can obtain more precise local details such as the severity of snow drifts by telephoning the county offices of the N.F.U. Such a service does attempt to overcome the two problems of the necessity for local forecasts and the difficulty of communication to the individual.

It is unfortunately true that the ideal method of a personal briefing of a farmer by a forecaster (such as is available to aircraft pilots) is not practicable. The next best solution is a frequent broadcast of detailed local weather forecasts, but radio time and wavelengths are so crowded that it is extremely difficult to accomplish this.

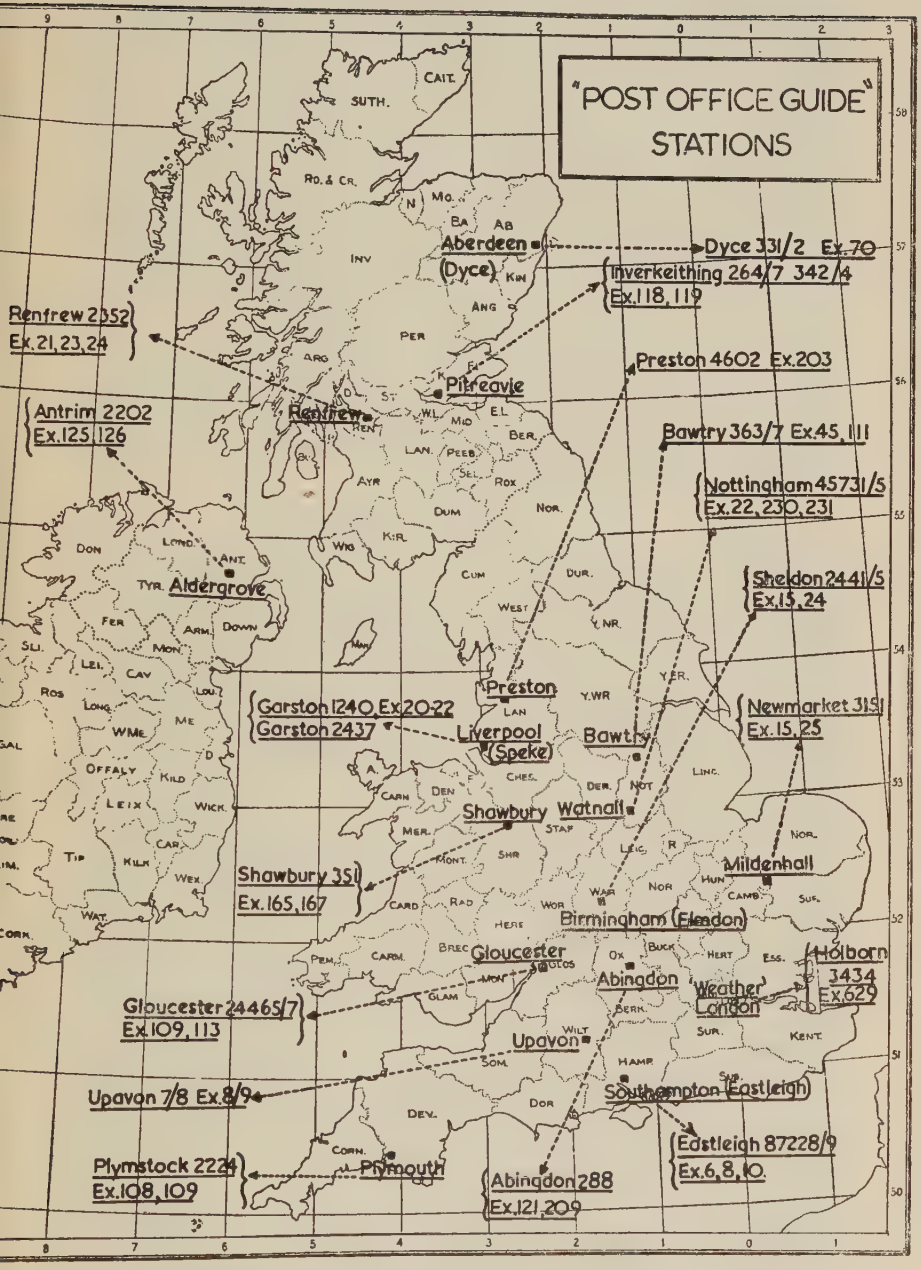
The duty of the Agricultural Branch in relation to forecast services is thus twofold—firstly, it must acquaint the farmers with the services available; secondly, it must inform the forecasters as to the type of forecast which a farmer requires.

The Use of Existing Data

Forecasts for the British Isles cannot cover a period of greater length than one or two days, except in very settled weather. Forecasts for longer periods are still in the experimental stage, and seasonal forecasts are not yet possible. Thus, in order to find out the range of weather that can be expected in any season, it is necessary to examine the past records. The Meteorological Office handles the data from nearly 400 climatological stations and over 5,000 rainfall stations. Summaries from such records are usually published in the form of averages, but this form of presentation is only the initial step in so far as agricultural needs are concerned. A large part of the work of the Agricultural Branch consists in examining these data, not only to enable them to make a critical survey of a given farm, but also to publish climate summaries which emphasize the factors which are significant to agriculture. For example, papers have been prepared for the N.A.A.S. provinces of south-west and south-east England which show the probability of a dry spell of a given number of days occurring during the summer, with special reference to harvest problems. Similarly, the variations in monthly rainfall, and the frequencies of dry months or successions of dry months, are being prepared for the main horticultural areas such as Kent, the Vale of Evesham, etc. Summaries of soil temperatures, sunshine spells and wind records are also being prepared, the aim in each case being to provide statistics which are in the most convenient form for application to agricultural problems.

Ultimately, a series of such summaries will provide a form of reference whereby the climate of any area from an agricultural standpoint can be ascertained. Until such publications are fully available, M.O.19 can meet any current needs by extracting such data as are required for any one purpose or area.

To enable officers of the N.A.A.S. to keep in touch with current weather, weekly weather summaries are prepared and circulated to some 400 addresses. Eight such summaries are prepared, one for each


"POST OFFICE GUIDE" STATIONS
Aberdeen (Dyce)
Dyce 331/2 Ex.70
Inverkeithing 264/7 342/4 Ex.118, 119
Renfrew 2352 Ex.21, 23, 24
Preston 4602 Ex.203
Pitreavie
Antrim 2202 Ex.125, 126
Renfrew
Bawtry 363/7 Ex.45, 111
Nottingham 45731/5 Ex.22, 230, 231
Sheldon 2441/5 Ex.15, 24
Aldergrove
Garston 1240 Ex.20-22
Garston 2437
Preston
Liverpool (Speke)
Bawtry
Newmarket 3151 Ex.15, 25
Shawbury
Watnall
Shawbury 351 Ex.165, 167
Mildenhall
Birmingham (Elmdon)
Holborn 3434 Ex.629
Weather London
Gloucester
Abingdon
Gloucester 24465/7 Ex.109, 113
Upavon
Upavon 7/8 Ex.8/9
Southampton Eastleigh
Eastleigh 87228/9 Ex.6, 8, 10.
Plymstock 2224 Ex.108, 109
Plymouth
Abingdon 288 Ex.121, 209

province of the N.A.A.S., and they are issued at the end of the week following the period under review. Each province is divided into appropriate districts, and for each district the week's divergence from average is given for temperature, earth temperature, rainfall and sunshine. Such divergences are quoted in preference to absolute figures because their values can be applied over a wider area, while absolute figures can apply only to the station at which they were observed. An additional advantage is that they give an estimate of the rain or cloud in relation to that which crops would be experiencing in a normal year, while the departures of the temperatures from average show the lateness or earliness of a season, and the magnitude of a warm or cold spell. A daily weather diary is included in the summaries, together with details of other weather statistics which are likely to be of current importance. The summary is designed to be a convenient form of reference whereby the office or laboratory worker can keep in close touch with weather trends. The statistics quoted are not precise enough to form the basis of a detailed investigation, but they enable the reader to see at a glance whether the problem could have been affected by a particular type of weather.

The Use of Existing Knowledge

An immediate example of the use of existing meteorological knowledge is in the measurement of weather elements. Considerable experience has been gained by meteorologists with respect to questions of instrumental technique, exposure, point-to-point variance and assessment of results. Their advice can often save the field experimenter much wasted effort or guard him from making unjustifiable conclusions. The Agricultural Branch visit all crop-weather stations to inspect the standard meteorological instruments, and they co-operate with the Directors of experimental farms and horticultural stations in the planning of additional special observations which may be needed in connection with particular investigations. For example, investigations on frost liability at Luddington, wind strengths at Stockbridge House, and soil temperatures at High Mowthorpe have been arranged. Fundamental meteorological research, or work which has been carried out to meet aviation requirements, often has a pronounced bearing on agricultural problems. A case in point is the information available regarding the behaviour of wind in the neighbourhood of obstacles such as buildings, hedges, or the ground itself. Such information is invaluable in the consideration of the question of wind-breaks or shelter-belts, the problems of spraying, the dispersal of spores, or the movement of small insects. It is in this type of problem that an immense amount of correlation of existing research papers has to be done; many references and cross-references have to be followed up to ensure that the maximum use is being made of any previous work. By this type of liaison much useless duplication of research can be avoided.

Similarly, the work that is being done by Government scientists on subjects such as the heat loss from buildings has a direct application to the questions of the design of glasshouses, stockyards, piggeries

and poultry houses. The meteorologist is in a good position to act as a liaison officer in these matters, because his basic subject of weather is of such universal importance that he should be cognizant of the fundamental problems, their magnitude, and the best methods to be tried for their solution.

Briefly, there is hardly a subject of agricultural research in which meteorology does not play a part. It has been the experience of the Agricultural Branch that much valuable help can be given by application of the knowledge already at their disposal; still more do meteorologists need further knowledge of weather and climate in specific relation to agricultural problems.

Research

The problems that have to be faced are enormous in extent; the field for research in microclimate and ecoclimate demands many years of accurate field work and the careful analysis of results. At present the most that can be done is to ensure that the help and advice of the meteorologist is available in the planning of experiments. Close co-operation between the meteorologists and the agricultural research scientist is, therefore, essential.

Recent field work has been concerned with problems such as the variation in climate over level ground and on a hillside, the frost liability of orchards, temperatures under glass, and the wind speeds behind shelter-belts. The question of frost liability is a meteorological one; the question of frost protection lies more in the province of the agricultural engineer, because the main difficulty is not just the protection from frost, but protection on an economic scale. With regard to frost liability, information of a quantitative and qualitative nature is gradually being amassed with the aim of making a reliable assessment of the liability of any given site to frost. Experiments on temperatures under glass have shown that the gain in minimum temperature under glass (the degree of frost protection) is relatively small unless additional protective measures are taken. The gain in maximum temperature under glass depends on the time of the year and the incidental sunlight, and can be calculated to a fair degree of accuracy. The amelioration in the temperature profile is largely due to the drop in wind strength occasioned by the surrounding glass; the decrease in outgoing radiation seems to play a far smaller part. It is the importance of this factor of decreased wind strength that is so important in the question of shelter-belts. The amount of damage or retardation in crop growth due to wind is rarely noticed until it becomes serious, and the loss of heat from a greenhouse is far greater in areas of strong winds. Wind erosion of soil was a very serious problem over large areas of East Anglia during the dry 1949, and it is possible that in that area the process of deforestation and the grubbing-up of hedges has increased beyond a sensible limit.

Calculations have recently been made to assess the water needs of crops, and it is beyond doubt that shallow-rooted crops are in need of extra summer water over most of England almost every year.

The meteorological factors of wind and water probably play a predominant part in the determination of crop yields, and both factors are to some extent controllable. The main disadvantage of most forms of glass protection is that it prevents even the inadequate summer rain from reaching the crop. Problems of the amount of water required can possibly be solved with the aid of a meteorologist, but problems of the method of adding water by irrigation lie in the biological and engineering fields.

Education

In order to perform his duties efficiently, an agricultural meteorologist must acquire a working knowledge of agriculture. In the course of his work, by selective reading and constant discussion, he attains a good background appreciation of the general principles and problems. On the other hand, it is also true that a farmer or agricultural scientist should have a sound knowledge of elementary meteorology. There are probably few subjects which are so universally discussed as meteorology, and yet about which such widespread ignorance exists. Several lectures have therefore been given by the Agricultural Branch to students, growers, etc., with the aim of presenting meteorology in its true perspective. Meteorological displays have been shown at the Market Produce Show at Southampton for several years, and the Branch are always willing to co-operate with the Ministry of Agriculture in a display at any show. The illustration on page iv of the art inset shows a model of a shelter-belt in a wind tunnel which was on display at the Natural Science Museum for the exhibition held in commemoration of the centenary of the Royal Meteorological Society. Small indicators showed the wind speed, and the drop in speed caused by the erection of a hedge was clearly demonstrated. Much still remains to be done on this educational side, for full advantage cannot be taken of the existing meteorological facilities without the full co-operation of both sides.

The Future

The whole future of agricultural meteorology in this country can be aptly summed up in the Spanish proverb " Lose nothing for want of asking." If the agriculturists feel that meteorological help is required of the type that has been outlined in this article, then a demand for such help must be raised. The meteorologist himself feels that he has much to offer the industry, but it is up to the industry itself to ensure that such help is available.

CORRECTIONS

N.A.A.S. Quarterly Review No. 6, page 68. Fruit abstracts: Out of Season Strawberries.

To correct an error in trans'ation, the intensities of light in para. 2 should read as 10-foot candles, and those in paras. 3 and 4 as 40- to 50-foot candles.

N.A.A.S. Quarterly Review No. 10, page 73. Crop Husbandry Abstracts: Combine Harvesting.

The reference to U.S.D.A. Farmers' Bulletin should read No. 1761, not No. 1961.

ABSTRACTS

ANIMAL BREEDING

A Study of some of the Factors influencing the Birth and Weaning Weights of Beef Calves. GREGORY, K. E., BLUNN, C. T., and BAKER, M. L. *J. Anim Sci.*, 1950, **9.**

The importance of assessing the breeding value of animals has long been recognized. If visual conformation in early life was an expression of later breeding capabilities, then this factor would be of value in selection.

The purpose of this study was to find which factors were concerned in influencing the birth weight, weaning weight and the gain from birth to weaning of beef calves, and to determine the value of these characters in selecting for improvement in the performance of beef cattle.

Data used was collected from sub-stations of the Nebraska Agricultural Experiment Station during 1936 and from 1944-1947. A total of 270 birth and weaning weights was collected—the progeny of six sires. All the calves were sired by pure bred Hereford bulls and were from high grade Hereford dams.

The results show that there was a significant difference in the birth weight between the sexes, but this difference between sexes did not exist for rate of gain or for weaning weight. The heritability of the half brothers and sisters was high between sires for birth weight and moderately high for weaning weight but there was no, or very little, significance for gain from birth until weaning.

The weight of the cow influences the weight of her offspring and the cows making the smallest gains during the nursing period tended to produce calves making the greatest liveweight gains from birth to weaning.

Cows tended to repeat their previous performance for gain of their calves during suckling and this made weaning weights more constant than birth weights.

Gain from birth to weaning is greatly influenced by environmental factors ; such factors as the milking ability and the mothering qualities of the dam, are highly significant in the beef cow.

The Extension of Record of Performance in Beef Cattle. MUIR, J. *J. Anim. Sci.*, 1950, **9.**

A beef cattle improvement programme was started in the State of Washington in 1945. Standards were agreed upon and selection committees divided bulls into four grades. After a few years, stockmen became grade conscious and selected bulls from breeders producing the higher grade bulls.

At this time several breeders became interested in performance records, and through the Extension Service a system has been evolved

for assessing the value of animals as producers of beef. The sires and dams are graded in early autumn, a permanent record is made up for each sire and dam, calving is kept to one time of the year and the calves are weaned and graded at 7 months of age. Calves are then placed on a uniform diet for 5 months and are then graded and gain and type are noted.

The aim is to get sufficient herds recording under the scheme so that breeding stock can be bought from approved lines. It is to be hoped that in future the value of cattle will be assessed as much from their rate of liveweight gain as from their prowess in the show ring.

W.L.

ANIMAL NUTRITION

Judicious Use of High Quality Feedingstuffs

When concentrates are restricted in quantity, it is natural to seek the most efficient ways of using them. The powers of the animal body to store protein for later use are limited, and wastage is caused unless the supply is made to synchronize with the need.

The steaming-up of a cow before calving is a case in point. Mammary tissue begins to grow towards the end of the fifth month of pregnancy and its growth can be increased by extra feeding, hence the size of the udder (and therefore its capacity for milk manufacture) can be determined by the quality of the feeding in late pregnancy. Some results of Blaxter[1] may be quoted. Cows, each fed 156 lb. of concentrates during six weeks before calving in addition to a basal ration, gave 7 lb. more milk per day than cows receiving the basal only. The effect of feeding an extra 4 lb. of concentrates daily in mid-lactation was to increase milk production by only 1 lb. per day, and underfeeding to the extent of 4 lb. of concentrates caused a fall of only 2 lb. in the milk produced. Thus it was shown that when concentrates are in short supply, it is better to take them from cows in mid or late lactation than from those about to calve.

Wallace[2], working with Hammond at Cambridge, has made a very thorough study of sheep. The first critical period in sheep-feeding is just before tupping. The reproductive organs of ewes that are well-fed for a few weeks before and during this time are so affected that the lamb-crop may be doubled. The second critical time is during the last two months of pregnancy, as has been shown in the following way :

> (*a*) one lot of sheep was poorly fed throughout ; (*b*) a second lot was well fed at first and then poorly fed during the last two months ; (*c*) a third was poorly fed at first and then well fed in the last two months ; and (*d*), a fourth was well fed throughout. The weight of the lambs from (*a*) and (*b*) was only about 60 per cent of those from (*c*) and (*d*) and the yield of milk over sixteen weeks was only about two-thirds, even although the treatment and feeding of all the ewes was the same after lambing. At sixteen weeks the (*c*)-(*d*) lambs weighed one-and-a-quarter times as much as the (*a*)-(*b*) lambs.

This work showed that extra feeding in early pregnancy produces no dividends but that such feeding is very much worthwhile during the last six to eight weeks. Unfortunately, this is the time when feeding is

poorest in hill flocks ; but, if trouble is taken to provide supplementary feeding at this time (which could be done without impairing the ranging habits of the ewes), serious losses could be greatly reduced, the vigour of both ewes and lambs increased, and the time required to fatten the lambs considerably shortened. Similar results have been reported from the Rowett Institute[3] where generous feeding during only the last month increased birth-weights by over a quarter. Further work at the Institute[4] has studied the effect of various levels of feeding upon the weight and health of the ewe and the survival of the lambs. At parturition, the worst fed ewes were receiving only one-quarter of the digestible protein and one-third of the digestible energy that were given to the best fed, and they had lost greatly in weight. Most of them suffered from pregnancy toxaemia (" twin-lamb " disease), a ketosis due to lack of carbohydrate.

The Cambridge workers[5] have also considered the economy of growth in the various species. The changes of shape associated with growth in the lamb can be so influenced by high feeding that an optimum stage is quickly reached. Thus, a lamb given high feeding throughout reached a carcase weight of 30 lb. in 56 days ; while one given high feeding for 42 days followed by low, and another given low feeding for 42 days followed by high, each required 125 days to reach this same weight. In pigs, the most economical method was to feed on a high plane for 16 weeks and then to drop to a low one ; this also produced the best quality bacon. Fattening by this method required 1⅛ lb. less meal per 1 lb. liveweight gain than did feeding on a low followed by a high plane. Recommendations were also made for growing and fattening cattle. Extra feeding in winter to maintain the weights gained in the previous summer might save a year's feeding, by allowing of marketing a year sooner. A steer losing weight in winter may be feeding on beef steak. The loss in weight can be prevented by a quarter of the amount of the feedingstuffs which were required to form that steak.

References

1. Blaxter, K. L. *J. Agric. Sci.*, 1944, **34**, 27-34.
2. Wallace, L. R. *J. Agric. Sci.*, 1948, 38, 93-153, 243-302, and 367-401.
3. Thomson, W., and Fraser, A. H. H. *Scot. J. Agric.*, 1939, **22**, 71-3.
4. Thomson, A. M., and Thomson, W. *Brit. J. Nutrition*, 1949, **2**, 290-305.
5. Hammond, J. *J. Inst. Corn & Agric. Merchants*, 1950, **2**, 165-76.

S.M.B.

DAIRY BACTERIOLOGY

Because of the importance of coliform organisms in agriculture in general, and in dairying in particular, the Report of the *Coliform Sub-Committee* of the *Society for General Microbiology and the Society for Applied Bacteriology* (*Proc. Soc. appl. Bact.*, 1949, No. 2, 3), should be read by all dairy bacteriologists. Apart from its reasoned simplifications of former classifications, the report is valuable for its detailed descriptions of media and methods, and goes far to resolve the confusion concerning the coliform group.

Temperature Compensated Tests for Raw Milk Supplies

In the same journal (p. 69) Clegg discusses a time-temperature compensated resazurin test for raw milk and points out that the scale of compensation of the present routine resazurin test is arbitrary and not based on experimental findings. He considers, with others, that resazurin reduction is not a reliable index of keeping quality and dilates upon the unreliability for the same purpose of disc readings. He proposes to base his own scale on time to reach disc ½.

A further paper (*ibid*, p. 79) reports similar work with the methylene blue test. Clegg concludes that this test, owing to the wide variation in reduction times for milks of similar keeping quality, is also not a reliable index of the keeping quality of milk.

Continued on p. 115

THE MINERAL NUTRITION OF CROPS

Illustrations

PLATE 1

(*a*) *Copper deficiency*. Young pear tree showing typical die-back of shoots. Note distortion of tip leaves, followed by defoliation which progresses basipetally.

(*b*) *Zinc deficiency*. Young flax plants. Typical symptoms are short internodes, small narrow leaves with necrotic areas and development of bare shoots with terminal " rosettes ".

PLATE 2

(*a*) *Molybdenum deficiency*. Cauliflower plant showing typical sequence of events, from large basal leaves with ragged margins to young leaves with undeveloped laminae (Whiptail condition). Plant grown with nutrient solution containing 350 p.p.m. N. and 0.00005 p.p.m. Mo.

(*b*) *Soil acidity effects*. Swede plants all grown with low level of calcium: from left to right—control, low calcium ; high manganese ; high aluminium ; high manganese plus high aluminium. Note severe effect of high manganese, slight effect of high aluminium and increased " manganese " effect in manganese plus aluminium treatment.

PLATE 3

(*a*) *Potassium/iron interaction*. Potato plants grown with low level of iron : centre, low potassium ; right, medium potassium ; and left, high potassium level. Note centre and right plants, chlorosis of tip growths ; left plant only slightly pale older leaves.

(*b*) *Soil acidity effects*. Sugar beet plants, showing typical effects of : right, calcium deficiency ; top left, high manganese ; bottom left, high aluminium. Unlike brassica crops sugar beet is highly susceptible to excess aluminium and fairly tolerant of high manganese.

Plate 1

(*a*)

(*b*)

Plate 2

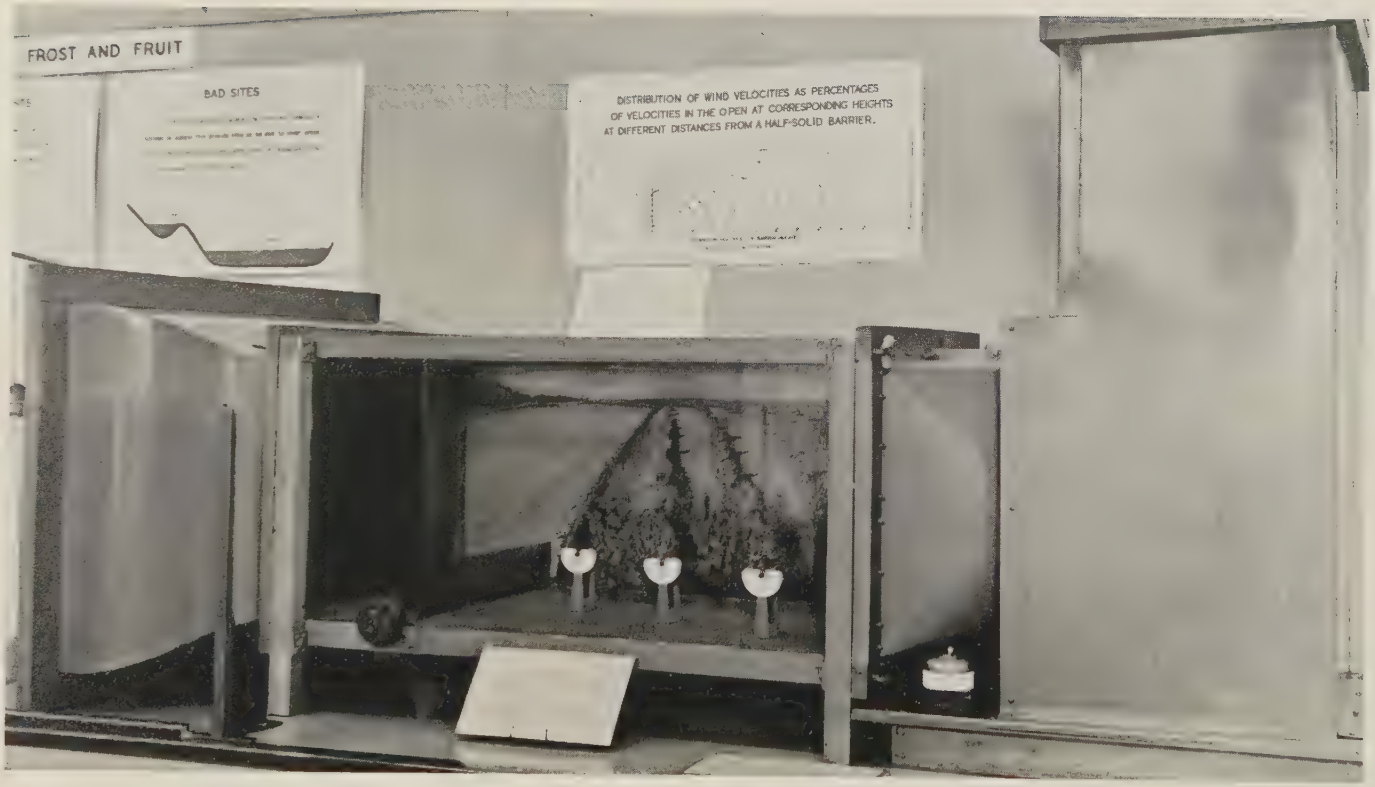
a)

b)

Photographs : *Long Ashton Research Station*

Plate 3

(*a*)



Model of a shelter belt in a wind tunnel, demonstrating the drop in wind speed caused by the erection of a hedge.

In a third paper (p. 87) Clegg and Thomas, with collaborators, report the results of a temperature-compensated methylene blue test, for a large number of samples. They recommend that, because the results obtained with mixed morning and evening milk are so inconsistent, in comparison with those for single milks, mixed milks be not used for advisory purposes. If for advisory purposes it were desired to secure the same proportion of samples failing to comply with the test throughout the year (say 10 per cent), it would be necessary to use separate compensation scales for winter and summer samples.

These papers should be read in full by those interested in milk testing.

The Effect of Bacterial Infection on the Yield of the Individual Quarters of the Cow's Udder. (*J. Dairy Res.*, 1950, **17**, 128).

Under this title Crossman, Dodd, Lee and Neave approach the important question of the effect of mastitis on the yield and composition of the milk of individual quarters of the udder. The work refers mainly to sub-clinical (latent or carrier) infections which are so commonly discounted and neglected.

Over 100 cows were used in the experiment and the milk yield of each separate quarter was recorded by means of a special milking machine delivering the milk of each quarter into a separate container. Samples of the entire yield of each quarter were taken for chemical examination and the first few jets for bacteriological examination. Each front quarter of a normal cow's udder yielded about 30 per cent and each hind quarter about 20 per cent of the total yield.

The proportionate yields of many quarters infected by streptococci and staphylococci decreased and the percentage of solids-not-fat was also reduced. But some infections with exactly similar organisms persisting for months caused no such effects. Sometimes the reduction in yield caused by an infection was small over a short period, but was shown to be severe when observations were continued over a longer period. Sometimes, also, an infection which lasted for a very short time caused marked decreases in milk yield which might have been attributed to other causes.

When infections were terminated by penicillin treatment the yield of milk did not usually return to normal in the current lactation, but the percentage of S.N.F. in some cases did and in some did not return to normal.

If, however, quarters were free from infection during the dry period the yield became normal in the subsequent lactation.

A.T.R.M.

POULTRY HUSBANDRY

Feeding

The increased cost of poultry food has led to keen interest in the employment of those substances which may result in its better utilization. It seems that by the regular use of certain recently discovered vitamin supplements, it may be possible to reduce the increased amount of food now necessary to satisfy the appetite of a bird without loss of efficiency, and so to offer one method of reducing costs. Apart from the interest displayed in A.P.F., and what appears to be its constituent, namely B_{12}, there are at present some grounds for optimism about the value of antibiotics. Several recent papers relate to the use of antibiotics in poultry foods and suggest the manner in which they lead to improved growth.

Whitehill, Oleson and Hutchings in a paper entitled " Stimulatory Effect of Aureomycin on the Growth of Chicks " published in the *Proc. Soc. exp. Biol.*, 1950, **74,** 11-3, describe how 25 mg. of aureomycin hydrochloride per Kg. of diet stimulated growth ; they point out that no effect followed when the antibiotic was administered intravenously. An article on " Further Observations on the Animal Protein Factor " by Stokstad and Jukes (*ibid.*, 1950, **73,** 523) deals with the same subject. They demonstrate the improved growth which followed the feeding of B_{12} and streptomycin aureofaciens, and also from fermentation cultures in which the aureomycin was destroyed. The growth response was better than that achieved by arsonic acid compounds.

Some indication of the manner in which antibiotics may lead to improved growth is found in two papers in *Poultry Science.* Kirkpatrick, Moses and Baldini in *Poult. Sci.*, 1950, **29**, 561-9, in " Streptomycin Studies in Ulcerative Enteritis in Bobwhite Quail, I," give an account of susceptible quail exposed to infection by ulcerative enteritis receiving treatment with streptomycin in the drinking water. The antibiotic exerted a marked effect, only 8 per cent of the treated birds dying as against 84.6 in the untreated group. In the same Journal (*ibid*, 1950, **29**, 520-6) Peppler, Oberg, Benedict and Lindenfelser discuss " The Effect of Feeding Crude Polymyxin D on the Intestinal Bacteria of Chickens." The antibiotic was fed at several levels. At the highest rate 2.5 per cent—the rate of growth was temporarily depressed, but at all stages the number of gram negative intestinal bacteria of the chickens was markedly decreased. The authors report substantial gains in weight after discontinuing the antibiotic supplement.

From the evidence of these four papers and other experimental work of a similar nature, it would appear that these antibiotic supplements act in destroying some harmful bacteria in the digestive tract (thus allowing better utilization of the food supplied), or possibly by stimulating the growth of some micro-organism which synthesises some needed factor —or both. The evidence presented does not suggest these supplements act as needed nutrients.

A related matter that is interesting poultry keepers turning to intensive methods is the value of deep litter as a source of B_{12}. In *Science*, 1950,

112, 308-9, Halbrook, Winter and Sutton in an article on " Built-up Poultry House Litter as a Growth Promoting Supplement for Chicks on an All-Vegetable B_{12} Deficient Diet," describe the increased growth found with chicks when screened corn cob litter over one year old was added to an all-vegetable diet. Autoclaving increased the response and it is suggested that autoclaving released a bound form of B_{12} or destroyed a toxic inhibitor.

In a most interesting publication by the U.S.D.A. Bureau of Agricultural and Industrial Chemistry, June, 1950, Binkley and Jasak give an account of the " Production of a Friable Meal from Feathers." They describe the process of manufacture whereby a friable product is obtained, and give some indication of the probable cost. The product may be used as a component for fertilizers or a plaster retarder, and the authors suggest that its value as a protein food supplement ought to be investigated in view of its high arginine content.

R.C.

CROP HUSBANDRY

Crops for Winter Grazing

A guide to the use of crops suitable for winter grazing is given by J. R. Stubbs in " Forage Crop Growing and Utilization " (*Agriculture*, 1950, **57**, 316-9). The crops listed include kale, rape, cereals, ryegrass and vetches. One full meal (1½ hours' grazing) of kale or rape, plus 6 lb. hay, suffices for maintenance and the first two gallons of milk, except for the Channel Island breeds. It is claimed that a system of winter grazing plus hay may lower the food cost per gallon of milk by 3d.-4d. per gallon, compared with traditional hay and cake feeding. The milk stimulating qualities of spring-growing cereals are emphasized, also the labour-saving possibilities of all-the-year-round grazing. A tabular guide to the growing of winter grazing crops is provided.

It is interesting to compare these opinions with those set out in an article called " Cereals for Greenfeed " in *N.Z. J. Agric.*, July, 1950, 33-8. The advice given to New Zealand farmers is certainly more precise than is generally possible in this country. The crops listed include oats, barley, wheat, rye, maize, millet, and sorghum.

In the September, 1950, issue of the same journal, information is given regarding the available strains of marrowstem kale, often referred to as " chou moellier." Mention is made of the greater resistance of marrowstem kale to Finger-and-Toe disease compared with turnips and swedes, and to its greater suitability to dry areas.

Spray Chemicals

In an article " Pest Killers must not be Men Killers " (*World Crops*, 1950, **2**, 474) W. E. Ripper lays down essential rules to observe when spraying insecticides, fungicides and weedicides. He lists an eight point safety code and points out the serious risks with certain materials if

these are not observed. He goes on to say that spray operators must be well-trained and skilled workmen who are thoroughly safety-conscious ; further, there must be constant technical supervision of all spray operations by fully qualified personnel. He mentions safety legislation in the U.S.A. and talks of the establishment of " tolerances of toxic residues." The suggestion is made that those responsible for spraying services must realize, and be prepared to shoulder, their responsibilities, or otherwise restrict their spraying operations to the use of non-toxic spray chemicals. Dr. Ripper makes many strong points in his article. One such vital point is that in the most progressive countries it has become a legal requirement for a contractor to obtain a licence before he operates—this is not granted unless he is professionally qualified or has passed a rigorous examination by a board set up by the agricultural administration.

Another item dealing with weedicides is provided under the title " The Control of Buttercups in Permanent Pasture " by S. J. Willis (*Agriculture*, 1950, **57,** 359-64). He concludes that the tall, creeping and bulbous species of buttercup can all be controlled with about 1½ lb. per acre of MCPA or 2.4D, and that more than 2 lb. should never be used. Early applications (March to April) probably give best control, but for the sake of the clovers it seems advisable not to apply the weed-killer until the buttercups are beginning to flower.

P. J. O. Trist and W. A. Hayles have circulated a cyclostyled account of some observations made on the control of the Lesser Broomrape (*Orobanche minor*) in East Suffolk. They sprayed the plant growing in a field of broad red clover during July with sulphuric acid and with DNC, both at 100 gallons per acre. The sulphuric acid was used at strengths varying from 15 to 100 per cent B.O.V. The purpose of spraying was to destroy the viability of the seeds of the weed and thereby prevent a source of further infection on the field. There was a certain amount of evidence that solutions of over 25 per cent B.O.V. can be effective in destroying the seeds, but the cost of material may make this an uneconomic method of control.

Rabbit Damage to Cereals

Losses caused to crops of winter sown wheat and oats are discussed by H. C. Gough and F. W. Dunnett in an article called " Rabbit Damage to Winter Corn " (*Agriculture*, 1950, **57,** 374-8). They produce evidence to show that rabbits commonly graze large areas of corn during the winter so that whole fields appear bare, despite the seeming lack of rabbits in the neighbourhood. The rabbits may, in fact, travel half-a-mile or more to graze crops. If the grazing is persistent, the plant population may be reduced by as much as 80 per cent, so that complete failure of crop can result. Ripening of a seriously grazed crop may be delayed by 10 or 18 days.

G.E.F.
D.H.R.

VEGETABLE CROPS

Professor T. Laine's Frost Protection System. KOBEL, F. *Schweiz. Ztschr. Obst- u. Weinb.*, 1950, **59**, 155-6.

A Modern Method of Frost Protection. GERBER, H. *Ibid.* 181-5.

Frost Protection Studies. WINKLER, H. *Arsb. svensk Jordbr. Forskn*, 1950, 122-3.

Professor Traumo Laine of Finland has developed a method of protecting crops from frost using artificial fog generated by the action of SO_3 and water vapour. Fog is much more effective than smoke as a blanketing screen because the relatively large particles of water in the fog allow less heat to pass between them than do the smaller more widely dispersed particles in smoke. The fog layer must, of course, be laid down before the temperature of the air falls to freezing point.

The equipment is cheap and simple and is under commercial production in Switzerland. One generator will cover two acres of hilly country or up to 40 acres of flat land.

A Swedish frost research station has been established in a region which averages over 20 nights of frost between May and September. Under field experimental conditions artificial fog afforded complete protection to potatoes while neighbouring unprotected plants suffered severe damage.

Frost and Fruit Trees. HOARE, E. R. *Farming*, 1950, **4**, 141-4.

The Protection of Orchards from Frost. COURSHEE, R. J. Report published by *Nat. Inst. Agric. Eng.*, 1949.

These authors survey the ways in which frost damages fruit crops and the methods which have been used to prevent this damage.

Investigations now being carried out by the National Institute of Agricultural Engineering at Wrest Park indicate that the use of large low-powered horizontal fans may prove an effective economical means of protection. Under suitable conditions a single fan will raise the temperature in an acre of orchard by 3°-8° F. at negligible cost. The fans are most effective under conditions likely to result in radiation frost, but are relatively ineffective against wind-borne frost. Their performance is not yet good enough, however, for commercial application.

Other methods of protection from frost briefly discussed in these papers include the use of oil heaters, irrigation, water from sources above freezing point, smudging (smoking) and the heat conserved in the soil itself.

E.J.W.

Note. Further abstracts on frost damage will be found under "Fruit."—(*Ed.*)

Iron Deficiency

Both annual and perennial horticultural crops, when grown under certain soil conditions, are susceptible to a leaf chlorosis due to iron deficiency. In this country, the soils most commonly affected are those with calcareous subsoils (although there are many exceptions to this), and secondly those which have, in one way and another, been contaminated with heavy metals such as copper or zinc.

It has been established that in chlorotic leaves, iron is present in adequate amounts but is unavailable for metabolic purposes. In the light of this, it is more convenient to think in terms of active iron as opposed to the total amount present which may or may not be available. Current investigations being made on the nature of these problems are disclosing many of the factors which are at work in causing the unusual visual effects observed in crop growth.

Experiments on Iron Metabolism in Plants. I. Some Effects of Metal induced Iron Deficiency. HEWITT, E. J. *Ann. Rept. Long Ashton Res. Sta.*, 1948, 66-80.

In sand culture experiments, metals such as manganese, copper, chromium and cobalt were given to tomato, potato, sugar beet, oat and kale. Iron deficiency was induced by all these metals although the severity of the symptoms varied according to the plant and metal. Sugar beet stands out as an indicator plant suitable for such trials. The chlorosis, typical of iron deficiency in the potato and tomato, was produced by excess of copper, whereas the effects of cobalt and nickel were different and unlike the usual leaf pattern expected. Results are described of the manganese-iron relationship, and no evidence was found to confirm the belief that excess of one metal could induce a deficiency in the other. So far as could be ascertained, each of these two metals has an independent function in the plant. It was found also that two metals in the presence of each other accentuated the chlorosis in sugar beet. A distinction is made between the effect of the metal-inducing iron deficiency and toxicosis, due to the metal itself, and it is in this respect that only the visual symptoms on the leaf can indicate these two distinct phenomena. It is pointed out that the problems of metal-induced iron deficiency are complex and no known hypothesis seems capable of explaining the results observed.

Experiments on Iron Metabolism in Plants. II. The Interrelationship of Iron and Potassium in the Metabolism of the Potato Plant. JONES, E. W. and HEWITT, E. J. *Ann. Rept. Long Ashton Res. Sta.*, 1949, 49-57.

The potato (var. Majestic) was grown in sand cultures and supplied with different levels of iron and potassium in combination. At the lowest iron and potassium level, chlorosis typical of iron deficiency was produced; increasing the potassium supply almost eliminated this

chlorosis and gave a tall, vigorous, pale-green plant. With low potassium and levels of iron from low to high, symptoms of potassium deficiency were recorded, apart from a time lag in the appearance of symptoms in the high iron series.

The yield of tubers increased as the concentration of the two nutrients was raised. The total yield of the plants in the low iron/high potassium series was 36 times as great as in the low iron/low potassium group, although the yield of tubers remained similar in both cases. The chemical data for soluble iron or active iron indicated that, at the high potassium levels, the leaves contained more soluble iron. These experiments establish conclusively a relationship between potassium and iron, and a hypothesis is suggested that an adequate intake of potassium may stimulate the production of organic acids which, in turn, lowers the *p*H of the cell sap and thereby increases the availability of the iron.

W.P.

FRUIT

Water Sprinkling against Frost Damage

The control of spring frost damage to fruit by the use of continuous sprinkling with water is fast approaching the practical stage, though the only research report that has recently appeared is that by W. S. Rogers and Irena Modlibowska (1949 *Ann. Rept. E. Malling Res. Sta.*, 1950, 63-8.)

The protective effect depends on the transfer of heat from the added water, mainly by the release of latent heat, some 80 calories per gramme, when it turns into ice. This heating effect is equivalent to about 1,440,000 B.Th.U. per 1,000 gallons of water.

Detailed laboratory trials established that the continuous application of water could prevent the temperature of blossoms falling below 30° F. in an air temperature of 26.4° F.

In May, 1949, the first field scale trial was undertaken, using a Kinnell oscillating spray line and dwarf pyramid apple trees. This showed that the ice formed on flowers and leaves as a result of six hours' sprinkling at a temperature falling to 28° F. did not cause any mechanical damage to the blossoms or other parts of the tree. In this experiment about 1 inch of water was applied and a count of damaged blossoms showed a marked contrast in favour of the sprinkled trees. The frosts during May were not, however, severe enough to prevent the setting of a good crop even on the untreated trees. The sprinkling cooled the soil slightly to a depth of 4 inches, but no harmful effects were found ; in fact, the grass sward under the trees appeared to benefit during the following rather dry season. It is possible that newly cultivated soil might become sodden under such applications.

The authors conclude that before sprinkling with water can be generally recommended for frost damage prevention, methods must be devised for applying small quantities of water continuously at a fairly low capital cost.

Small-scale experiments have been carried out at Oxshott, Surrey, by Mr. J. H. Jeffree (*Royal Horticultural Society Fruit Year Book* 1950, 100-4), since 1945, mainly on apple and pear trees in his garden. Calculations from physical data encouraged him to try applications of water at the rate of one-tenth inch per hour. He accordingly devised a rotary sprinkler, mounted on a pole, that delivered this amount and covered a circle 16 yards in diameter. Before this equipment was completed the first severe frost of 1945 occurred and parts of two trees only were protected by a misty spray from a fixed nozzle. Subsequently during 1945, the rotary sprinkler was successfully used on frosty nights.

In 1948 there was a further opportunity of testing out the equipment, which was put on a taller pole so that a wider area was covered at a lower rate of watering (1/12th inch per hour). The crop picked in the treated area was about one-third of a full crop, and some trees outside the area also bore some fruit.

In 1949 further experiments were carried out, and on the basis of all these experiments Jeffree concludes that overhead irrigation at rates of application from 1/10th inch per hour upwards are effective on apples and pears. His results with other fruit (a plum tree and red and black currants) were inconclusive.

Although treated trees were heavily loaded with ice on the morning after the frost, branch breakages were very slight in spite of light pruning. No harmful effects that could definitely be ascribed to the heavy watering were observed.

Jeffree calculates that the droplets should be smaller than 1 mm. to achieve the best results, although at the edge of his sprayed area the drop size was 1.6 mm. and proved effective. He considers it is important to begin spraying as soon as the frost begins. He suggests that the water has a warming effect on the air as well as on the blossom and in a large area these effects might be additive ; it might, therefore, be possible to get protection with a smaller amount of water.

He considers the capital cost of protecting commercial fruit may be large and his equipment, which is the subject of a patent application, may be more suitable for small areas. Ordinary rotary sprinklers may also serve under these conditions, though they usually apply more water than he considers necessary.

The use of water-sprinkling for frost damage control seems to be gaining favour in the U.S.A., especially for soft fruit where irrigation equipment is needed for watering, but there have been no reports of controlled experiments. An account of the use of this method on strawberries was recently given by Jerry H. Mandigo, a district horticultural agent for South-Western Michigan. (*Amer. Fruit Gr.*, 1950, **70**, 30-2). He tells how growers had tried smudge pots, aeroplane propellers, airblast sprayers and other equipment without much success. The infra-red frost prevention machine developed at Michigan State College was too

expensive for most of the growers and they had turned to the possible use of water. The first attempts employed sprinklers that were moved during the night to cover as many acres as possible and the results were uniformly poor. In 1948 and 1949 more progress was made, especially by a grower of Bangor named Don Piper who used regular irrigation sprinklers to save a part of his strawberry bed. In 1949, four severe frosts gave the irrigation a good test and in spite of temperatures dropping to 23° F. and ice formation up to half-an-inch on blossoms and leaves, no damage was done. The news was put out to growers on the radio after the third frost, so that when the final and most severe frost in 1949 came, nearly every strawberry irrigation system in the area was in operation.

On the basis of his experience the following advice was given : Use small-capacity sprinklers but cover all areas of the field ; start irrigating when the temperature falls to 34° F. and go on applying water till the temperature rises above 32° F. The temperature of the water is immaterial and both well and lake water are suitable.

H.B.S.M.

Note. Further abstracts on frost damage will be found under " Vegetable Crops."—(*Ed.*)

FLOWERS

The Influence of Daylength and Temperature on the Growth and Flowering of Callistephus Chinensis Nees. Lok-Chien Lin and Watson, D. P. *Proc. Amer. Soc. hort. Sci.*, 1950, **55**, 441-6.

The China aster, often grown as a pot plant or cut flower for late winter, is greatly influenced in its flowering by the length of the daily light period and the temperature at which it is grown.

In this study, plants of the variety Sensation were grown in sandy soil at 50° F. and 65° F. Artificial light from a 60-watt, 120 volt incandescent lamp, suspended 2½ feet above the plants, was used on 30 plants in each group for five hours after sunset from December 6 to March 31. There were thus four groups of plants : (*a*) low temperature—long day, (*b*) low temperature—short day, (*c*) high temperature—long day, and (*d*) high temperature—short day. Time of flower-bud initiation was determined by sectioning stem apices and records were kept of time of first appearance of buds and blooms and of diameter and height of plants. The approximate number of days from seed-sowing to bud initiation in the four groups was (*a*) 68, (*b*) 98, (*c*) 68, (*d*) 83, and to the first bloom (*a*) 165, (*b*) 192, (*c*) 165, (*d*) 179. Increased daylength hastened flower-initiation by 30 days at the lower temperature and by 15 days at the higher temperature, but had no influence on the subsequent time to flowering. Growth was, however, more rapid at the higher temperature and stems were considerably longer. The best pot plants for market were produced under the low temperature—long day treatment.

The Effect of Hot Water-Formalin Treatment on the Forcing Qualities of Wedgwood Iris. KALIN, E. W., and COURTNEY, W. D. *Proc. Amer. Soc. hort. Sci.*, 1950, **55**, 455-7.

Bulbs of Iris variety Wedgwood, 10-11 cm. in diameter, were dug on July 27 and on August 10. At intervals after lifting, batches of bulbs were given warm-water treatment of 3 hours at 110° F. with 0.5 per cent commercial formaldehyde solution added to the water. The bulbs were air-dried and stored until November 6, when they were boxed and kept outside under sand, soil and 12 inches of straw. Forcing began on December 26 at 50° F. night temperature.

The earlier-lifted bulbs in all cases gave better quality flowers. The most striking fact with regard to treatment was that a critical time was reached some time between September 7 and September 21 in both lots. Bulbs treated after September 21 were definitely injured and failed to grow. The injury appeared to be to the basal plate as few, or no, roots were produced. Seasonal maturity of the bulb appears, therefore, to be of critical importance in relation to warm-water treatment. The number, but not the quality, of flowers was slightly reduced by warm-water treatment carried out before the critical period.

R.H.S.

HERBAGE

Lucerne

An extremely small quantity of lucerne seed is harvested in this country and it is of particular interest when information is received describing the range of types and varieties of lucerne which are available in those countries from which we purchase our seed. France is again becoming the chief source of seed sown in Britain. In this respect two recent papers by Mayer[1] and Davis[2] are of particular interest as they give an account of strains and varieties of lucerne grown in France and the general methods of culture in that country.

Mayer draws attention to the fact that the present-day cultivated lucernes belong to two broad divisions ascribed to *Medicago sativa* and *M. falcata*. The former are localized around the latitude of 40° and the latter between latitudes 30° and 60° N. The overlapping of areas of occurrence has given rise to hybrid forms and the majority of the cultivated lucernes of northern and western Europe and North America have been derived from hybrid stocks.

Variation in strain and hybridization has enabled lucerne to be grown under a wide range of conditions. In hot climates strains developed from the hairy Arabian types may thrive. In intermediate conditions with mild winters is found the Mediterranean type as in southern France, Italy, Spain, Hungary, Argentina, and South Africa. Strains derived from the hybrids orginating mainly from German and Russian types have extended lucerne northwards to Canada and Scandinavian countries.

Mayer considers that lucerne grown in France consists of three groups :

1. *Provence lucerne*, mainly harvested in the Rhone valley, belongs to the Mediterranean type. It is a semi-erect type recovering rapidly after cutting and typically possessing a pronounced tap root. The proportion of variegated flowers is very low or non-existent. It is not as productive or as winter hardy in the Paris region as strains developed locally, although in the south of France it is long lived. Davis reports that lucerne is left down for five to eight years or longer in the Rhone valley.

2. *Western lucerne* is comprised of two principal types, the Poitou and Marais. They are grown mainly in Poitou, Vendee, Anjou and the Charentes. This type is similar in vegetative characters to Provence but a proportion of plants cease to vegetate in the winter and produce a rosette of leaves. It has a higher proportion of variegated flowers than the other two French groups. The Poitou and Marais types are distinguished by their root structure, the former having pronounced tap roots like the Provence, and the Marais possessing roots the majority of which are fasciculated (branched). Western lucerne is less sensitive to cold than Provence.

3. *Flemish lucerne* is erect growing, possesses thicker stems than the other groups, and generally is a coarser plant with a lower proportion of leaf to stem. It is more winter-hardy than the other French groups of lucerne, although slightly less so than Grimm. It is none the less sufficiently winter-hardy for the north of France. In the proportion of variegated flowers it is intermediate between the other two groups, and its root structure is generally fasciculate. This group is remarkable for its vigorous growth which has been reported also from Scandinavian countries. Within this group there are naturally and artificially selected types such as Ormelong, Chartrainvilliers, Isle de France and Du Puits. Flemish lucerne appears less persistent than others. In the north of France lucerne is used as a two- or three-year ley.

Recently, French legislation has been introduced to set up a register of named varieties of lucernes [3]. The list contains initially the three general types as described by Mayer, namely, Provence, Poitou and Flamande (Flemish). A strain may be distinguished by a supplementary name following that of the general type, e.g., Flamande Chartrainvilliers. However, definable types may be registered by name without reference to the general type, e.g., Ormelong and Du Puits. With the existence of known races and varieties within French lucerne as a whole, the adoption of registered descriptive names for recognized types should be welcomed by farmers, seed merchants and advisory officers in Britain.

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2. Lucerne in France. Davis, A. G. *J. Brit. Grassland Soc.*, **5**, 47-62.
3. Setting up in France of a Register of Named Varieties of Lucerne. *Seed Trade Review*, **2**, Sept., 1950.

T.E.W.

Brown Rot of Fruit

R. J. W. Byrde[1] has continued the experiments started in 1947-48 on the control of Brown Rot of fruits. Laboratory tests confirmed that phenyl mercury chloride was the most effective fungicide in inhibiting the germination of spores of *Sclerotinia fructigena*. The other fungicides used in order of efficiency were : Phygon " XL," 8-hydroxyquinoline sulphate, copper 8-quinolinolate, Bordeaux mixture, Experimental Fungicide 341-C and lime-sulphur. A spraying trial was carried out on plums in late June, 1949. At picking on August 16-17, the following percentages of infected fruit were obtained :

Unsprayed Controls—3.25 per cent.
0.1 per cent copper 8-quinolinolate—0.87 per cent.
0.0035 per cent phenyl mercury chloride—0.37 per cent.
0.1 per cent Phygon " XL "—0.12 per cent.

All the treatments were significantly better than the controls, but there was no statistical significance in the difference between treatments. The phenyl mercury chloride spray caused slight brown necrotic spotting at the base of each fruit, while Phygon " XL " caused severe damage. No damage resulted from the copper 8-quinolinolate spray, but this material is much more expensive than phenyl mercury chloride. Tests of eradicant fungicides were made on detached mummified plums. The results indicated that 95 per cent of the Brown Rot pustules would be inhibited from sporulating by 0.3 per cent phenyl mercury chloride but at this concentration the cost of the material would be very high. Sodium pentachlorphenate and sodium dinitro-ortho-cresolate showed some promise, but in the field these soluble salts might be washed off if applied in the winter. Monocalcium and sodium arsenites again proved to be efficient eradicant fungicides.

M. H. Moore[2] has given an account of his experiments on brown rot of apples carried out since 1945. Trees of Cox's Orange Pippin were sprayed in the years 1945 and 1946. The fungicides used in 1945 were 0.2 per cent ferric dimethyl-dithiocarbamate, 0.1 per cent tetramethyl-thiuramdisulphide, 0.005 per cent phenyl mercury chloride, and in 1946 0.2 per cent of an 80 per cent dispersion of zinc dimethyldithio-carbamate replaced the TMTDS. In neither year did any treatment cause a significant reduction in the amount of Brown Rot. The author concludes that summer spraying is unlikely to give consistently good results, although success might follow if the time of spraying happened to coincide with a peak period of wound formation in the fruit.

Experiments were also laid down in 1946, 1947 and 1948 in order to study the different factors causing fruit damage that might precede Brown Rot. There were four different spray programmes :

1. Complete, including sprays for scab, sawfly and codling.
2. As (1) but omitting codling lead spray.
3. As (1) but omitting sawfly spray.
4. As (1) but omitting lime sulphur scab sprays.

The results showed that codling moth and Apple Scab were the chief precursors of Brown Rot. Apple sawfly was of negligible importance. Mechanical and other damage not controlled by the spray programme

was only a minor factor in the development of Brown Rot on the tree. Taking the mean for the three seasons, the percentage loss of fruit in each of the treatments was :

1. Complete spray—9.1 per cent.
2. Minus codling spray—21.2 per cent.
3. Minus sawfly spray—7.3 per cent.
4. Minus scab spray—19.5 per cent.

The author points out that the problem is different in the case of plums and cherries. With these, loss from Brown Rot occurs when the fruit is nearly ripe and easily damaged mechanically. He concludes that injuries not controlled by a normal spraying programme are more important factors leading to Brown Rot in plums and cherries than in apples.

In a popular bulletin for fruit growers Moore[3] discusses the results obtained in the previous paper and also some other aspects of the problem. He points out that in a wet season damage due to Apple Scab is likely to be at least as important as that caused by codling moth but that in a dry year codling moth causes most of the avoidable damage. He suggests that in a dry year, two codling sprays might be worthwhile. Results from commercial orchards indicate that birds and wasps may be important factors on some occasions. The possibility is suggested of Cox on M.IX being more susceptible to Brown Rot than on other stocks, due to the greater tendency of the fruit on this stock to crack. In plums, the possible importance of red plum maggot attack providing an entry for Brown Rot in some cases is mentioned. The author doubts if removal of rotting fruits from the trees is a practical means of reducing the source of infection in commercial plantations except in small isolated orchards.

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H.E.C.

ENTOMOLOGY

Observations on Blindness in Oats. Sheals, J. G. *Ann. appl. Biol.*, 1950, **37.**

The question of blindness in oats has been of importance for some years and many theories have been advanced to account for this condition. It is stated that spikelets in the lower third of the panicle are most susceptible to blindness and that the first formed spikelets are those in the upper portion of the panicle.

The author has examined the relative importance of various factors under conditions found in North Wales and concludes that frit fly is probably not the cause in so far as direct attacks on the developing

panicle are concerned. It is, however, regarded as likely, in the case of an early attack of frit fly on the growth of subsequent panicles, that the main effect would be a reduction in spikelet number.

Thrips, which have also been subject to suspicion, are now considered unimportant in relation to blindness, though they may affect the final yield through general weakening of the plant. Large numbers of thrips do not occur on the plants until late in the growing season.

Blindness is, therefore, considered to be due to adverse physiological conditions occurring during early growth ; it is possible that a variety of insects may have adverse affects on the growth of the panicles, although the panicles themselves may not be attacked.

Observations on the Beet Eelworm and other Cyst-forming Species of Heterodera. Jones, F. G. W. *Ann. appl. Biol.*, 1950, **37.**

This important paper, which is of considerable length, contains a great deal of new information concerning the important species of *Heterodera* which are serious pests. While the paper is of greatest interest to specialists in that group, the section dealing with host ranges is of more general interest and value. On pages 409 and 415 are to be found two tables which sum up the present state of knowledge regarding the host range, both for crops and weeds, of five species of *Heterodera.* The information relating to potato, beet and pea eelworm has a wide application. The tables show very clearly the very wide range of hosts attacked by the beet eelworm as compared with the small host ranges of the potato and pea eelworms.

Factors Influencing the Action of Dust Insecticides. David, W. A. L., and Gardiner, B. O. C. *Bull. ent. Res.*, 1950, **41,** 1-61.

This paper gives a very full account of a considerable amount of work on the mode of action of insecticide dusts.

Non-toxic dusts kill insects by causing them to lose water by abrading certain areas of the cuticle. The physical characteristics of such abrasive dusts are discussed in some detail. The factors which govern the adherence of dusts have also been investigated. It was also found that the most rapidly lethal dusts were those which caused the most rapid loss of weight. Insects conditioned to high humidity were found to be more resistant to the desiccating action of dusts than insects conditioned to low humidities. Abrasive dusts were found to be more effective carriers for DDT than non-abrasive dusts because the lethal effects of desiccation were added to those of the DDT, though there was no evidence that abrasive dusts facilitated the entry of DDT into insects as the result of damage caused to the cuticle. Dusts adhered to insects with rough surfaces to a greater extent than to those with smooth surfaces.

L.N.S.

VIROLOGY

Die Viruskrankheiten von Futter-und Zuckerrübe. HEINZE, KURT. *Natur and Volk*, 1950, **30**, 130-7.

In Germany beets are attacked by three virus diseases : beet mosaic which is present in all countries where beets are grown ; yellows which seems to be limited to Western Europe, and leaf curl which is very serious in Central Germany, Poland, and Czechoslovakia. Of these three diseases mosaic is the least important, yellows is a much more dangerous disease, whilst the most dangerous seems to be beet leaf-curl. Before control measures were found, leaf-curl made the growing of beets impossible in certain areas. About 20-30 days after transmission of the disease, the first symptoms appear in the form of a " clearing " of the leaf veins. The leaves are bent inwards and curl up, the young plants taking on the appearance of heads of lettuce ; growth ceases and the outer leaves quickly die. The insect vector is the beet bug *Piesma quadratum*. Apparently only the adults can transmit the virus and, once infected, retain infectivity for the rest of their lives. The damage to the sugar beet crop by the leaf curl virus can be very great, sometimes up to 75 per cent. The best method of control is by means of trap crops, using sticky boards as indicators of the migration of the insects to the plants. When migration is finished, the trap crop is ploughed deeply under, preferably early in the morning when the insects are quiescent. After ploughing, the ground should be rolled to prevent the insects coming out.

(This disease was first described some years before the second world war and was attributed to a virus ; later doubt was cast upon the virus etiology and it was stated to be due to a systemic insect toxin. Now it is considered once more to be of virus origin. If this is so, the virus is of potential importance, since the insect vector appears to be present in this country.)

Relationship between Certain Viruses Affecting the Genus Brassica. LARSON, R. H., MATTHEWS, R. E. F., and WALKER, J. C. *Phytopath*, 1950, **40**, 955.

The positive serological results obtained are evidence that the cabbage blackring virus (Tompkins), cabbage virus A, cabbage black ringspot virus (Smith) and horse radish mosaic virus are all serologically related, as shown by the precipitin tests, and confirm the relationship in this group established by other means.

The fact that the virus-antiserum precipitates were of the rapidly forming open flocculent " H " type indicated that the virus particles were rod-shaped. Examination of the specific precipitates under the electron microscope showed the presence of numerous rod-shaped particles. There was a correlation between the presence of rods in, and infectivity of, centrifuged sap from plants infected with viruses of this group. This association of rod-shaped particles with both infectivity and antigenicity suggests that strains of this virus group are long flexuous rods.

K.M.S.

The Relative Yields of Different Crops in Terms of Food and their responses to Fertilisers. *Agric. Prog.*, 1949, **24,** 14-24.

Yates and Boyd in this paper have tried to consider the balance between the different agricultural crops and the most effective use of fertilizers to give the increased production required for the expansion programme. In their introduction, they point out that world trade demands control the balance between production of food for animals and that for direct human consumption.

Figures for the relative efficiency of different farm animals in converting energy in food consumed to food for human consumption and the labour requirements of different farm animals are discussed.

Yields per acre of different crops are given, expressed in terms of dry matter, starch equivalent and protein equivalent. It is pointed out that dry matter does not provide a satisfactory index of energy production; three-quarters of the dry matter in grain represents available energy, while the figure for grass is one-half. The production of energy from a good grass crop in land which is not particularly suited to corn crops is likely to be double that obtained from a cereal crop. With heavy nitrogenous dressings and repeated cutting for silage or grass-drying, the yield of starch equivalent is three times that of the grain obtained in a cereal crop. The energy produced for human consumption when this is used by dairy cows is 60 per cent of the energy produced per acre by cereals grown direct for human consumption.

The energy equivalent of the total available supplies of food in the United Kingdom is given as 12.7 million tons starch equivalent for human consumption and 21.7 million tons starch equivalent for animal consumption. Calculations of the estimated consumption of food by farm animals obtained from the number of animals and the accepted feeding standards, gives a figure of 22.8 million tons starch equivalent. It is calculated that the efficiency of conversion of food for the livestock of this country is of the order of 9 per cent. Sixty per cent of the total energy produced is supplied by grass. Increased production in grass will mean an increase in farm stock and for the best utilization of the crop an increase in ensiling and drying is necessary.

Responses to standard dressings of nitrogen of different crops when expressed in tons of energy do not vary greatly and do not differ very much in different parts of the country. The responses to phosphate dressings, however, show greater variations due to soil type and climatic conditions. Variations in responses of different crops to standard dressings of phosphate are greater than with nitrogen, varying from 0.5 cwt. starch equivalent for cereals to 3.5 cwt. for swedes. Similar variations are obtained with potash. These are considerably reduced if farmyard manure is applied, but responses to nitrogen are about the same whether or not farmyard manure is applied.

A study of the figures obtained for quantities of fertilizers used, obtained from the Survey of Fertilizer Practice carried out in 1948, showed that in the arable areas root crops received substantial dressings of nitrogen, while only half the cereal area received any nitrogen. In the

grassland areas the rates of application and the fraction of arable area it was applied to is less than in the arable area. Variations are found in the application of nitrogen to grassland in different counties, dressings and areas treated being far below what is estimated to give the highest economical return.

By the use of an additional 80,000 tons of N on grassland and 20,000 tons N on cereals which do not now receive any nitrogen dressing, it is calculated that an additional 1.2 million tons starch equivalent, equal to 5 per cent of the present total energy production of the whole of the United Kingdom would be produced.

E.R.
W.M.D.

MACHINERY

Dairy Machinery

A new idea in the design of teat cups for milking machines, from a Friesian farmer named Bajema, is reported in *Farm Implement and Machinery Review*, November, 1950, 1,079. In 1929 this farmer turned to machine milking but was disappointed with the results obtained with a German machine. After making several alterations to the machine, he set out to design one himself.

The fundamental alteration in design is the manner in which the temporary vacuum air stroke is operated in the annular space between the metal teat cup and the rubber liner. In the ordinary machine this is effected by a single opening whereas, in the new idea, the entry is by two opposed openings that are connected by a Y piece of tubing to the temporary vacuum line. The liner is cylindrical and it is stated that when the air enters on the release stroke, the root of the teat is squeezed from both sides after the manner of the first finger and thumb in hand milking.

Perhaps of greater importance is the claim that a vacuum of 25½ in. of mercury, which is double that recommended when using the ordinary bucket type of milker, can be employed. Related to this is the claim that cows can be milked in two minutes.

The pails used in this machine are the type slung by a surcingle under the belly of the cow, and the claim is made that one person can handle 30 to 40 cows per hour, excluding stripping, which is done separately by a second man.

According to the article, Dutch cows are sensitive ; but the Dutch correspondent asserts that even after three years' milking by this machine, the udders were in the best condition. If all these claims are correct, it may mean that a considerable saving in time and labour can be effected.

Any claims that cows can be milked out in a specific time naturally recalls the tour made in this country by Professor Petersen of the U.S.A., during which he advocated the technique of quick milking, and left the impression that with proper preparation and training, cows could be

milked out in four minutes or less. In this connection, however, the series of articles by Dodd and Foot (*J. Dairy Res.*, 1947, **1, 2,** and 1949, **16,** No. 1,) and by Dodd, Foot and Henriques (1949, **16,** No. 3) should be read.

The studies in these articles comprise :

1. Effect of washing the udder with hot water.
2. Effect of reducing milking time.
3. Combined effect of reducing the milking time and washing the udder with hot water.
4. Effect of increasing the milking time.
5. Effect of temporary changes in the interval between washing and milking.
6. Comparison of established washing and milking routines.

These articles, which are very full and are the outcome of exhaustive research work, tend to show that the claims made by Petersen in respect of quick milking are not reproducible in this country ; in other words, cows have their individual rates of let down of milk, and these cannot be altered artificially, at any rate by the means attempted up to date. It will, therefore, be interesting to learn whether the changed construction of the Bajema machine, together with the doubling of the vacuum, can produce the claimed increased rate of milking.

A study of the rate of milking by machine has also been made by Whittleston and is reported in the *N.Z. J. Agric.*, 1949, **78,** 273-6. The ordinary bucket was replaced by a special cylinder fitted with 50 stainless steel studs at $\frac{1}{2}$-in. intervals. These were connected to an electric clock which operated a recording pen. As the milk level reached each stud, electrical contact was completed and a dot made by the pen. The article shows a number of graphs obtained under various conditions. If no stimulus is given to the cow, there is a definite time lag before milking starts, while at the apparent end of the milking, vigorous massage of the udder coupled with a pull on the claw, restarts the milking. It follows that effective stripping by machine can be obtained if the correct technique is employed.

Many farmers think that with slow milkers the addition of weights to the claw of a milking machine unit increases the rate of milking. This point has been investigated by Dodd and Henriques (*Agriculture*, 1949, **56,** 212-4).

Weights were used varying from 1 to 4 lb., with and without back straps. Beyond 4 lb. it was found that considerable irritation was caused to the cow and also that the assembly frequently fell off. It was concluded that with cows that milk slowly throughout the whole process and leave little stripping, additional weight produced no effect. The addition of weights produced some improvement with cows whose udder and teat construction permitted an easy crawl up of the teat cup. Apart from the above, it was concluded that for most cows the 7 lb. weight of the teat cup assembly is quite sufficient to ensure that strippings are kept at a low level.

The authors make the reservation that the results apply to one particular design of teat cup liner, and though changes in shape of liner are not likely to produce major changes in milking rate, they markedly affect the amount of machine stripping and the frequency with which the teat cups fall off the cow. The authors also confirm the observations of Maddaver and Egdell that in herds where back cords were used, the total duration of milking was high (*Agriculture*, 1949, **55**, 436-7).

C.E.E.
C.C.

PROVINCIAL NOTES

FORAGE CROPS FOR UPLAND FARMS

Albert J. Davies

National Agricultural Advisory Service, Wales

In the past the traditional method of disposing of wether lambs on most upland farms in Wales was to sell them as stores off grass to be fattened in lowland areas. With the outbreak of the 1939/45 war, large tracts of neglected land were brought into cultivation in many upland areas. The first essential on such land was to improve its fertility. This involved the application of lime and phosphates, and the sowing of pioneer crops. These crops served two purposes ; they provided valuable food for improving the quality of the livestock, particularly sheep, and indirectly, the grazing by livestock improved the fertility of the land. Upland farmers had an opportunity of marketing their wether lambs in a better condition than hitherto, and even of fattening them for direct sale to the Ministry of Food. After weaning, the lambs grazed on aftermath, and were finished off on a mixture of rape and hardy green turnips.

As more land was reclaimed and improved, more livestock were carried on these farms. With this increase in stock-carrying capacity, the provision of spring keep, as well as autumn grazing, became an important consideration. With this in view, Italian ryegrass was frequently sown with a brassica as a companion crop. A mixture of winter rye and Italian ryegrass was found to provide useful keep on heavy soils of low fertility. The aim in all cases was to provide an early spring bite, particularly for ewes and lambs, in addition to the fattening of wether lambs in the autumn.

In order to gain more information on the use of different pioneer crops under upland conditions, a number of grazing trials were carried out on Welsh farms during 1948 and 1949. These were intended to be

pilot experiments, designed to provide information on the practical aspects of the problem, prior to carrying out critical investigations. The same mixtures were used in all centres, and in each case these were grazed by Welsh Mountain wether lambs from hill flocks.

Grazing Mixtures

Four mixtures were sown at each centre, but it was not possible to graze every plot at all centres. The plots were :

		lb. per acre
Mixture 1	Winter rye	84
	Italian ryegrass	12
Mixture 2	Giant Essex rape	4
	Italian ryegrass	12
Mixture 3	Thousandhead kale	4
	Italian ryegrass	12
Mixture 4	Giant Essex rape	4
	Hardy green turnips	1

Each plot was 1½ acres in area.

The seed rates are considered to be on the light side, but where the cultivations were satisfactory, and adequate fertilizer dressings were applied, they proved to be ample. At each centre any lime requirement was made good, and the equivalent of 6 cwt. of 14 per cent superphosphate, and 1 cwt. sulphate of ammonia were applied. An additional top dressing of 1 cwt. of nitrogenous fertilizer per acre was applied at one centre. The rye seed was drilled at each centre, while the Italian ryegrass and the brassica seed were sown by a fiddle. After-cultivations consisted of a light harrowing and rolling.

The first trial was laid down in 1948 on a farm situated 1,000 ft. above sea level, on old red sandstone formation in north-east Carmarthenshire (Centre A). It was repeated in 1949 (Centre B) on another farm at the same altitude, on a similar soil formation in the same locality. The third centre (C) was in Merionethshire in 1949, on a farm situated about 600 ft. above sea level, with a medium loam soil derived from Silurian formation.

Composition of the Pioneer Crops

Just before the commencement of grazing, a quantitative analysis was made on all the ungrazed plots. The percentage productivity method was used to estimate the proportion each constituent contributed to the sample.

In Centre A weeds, particularly *Polygonum Persicarea* and *Lanium* sp., competed strongly with some of the mixtures. As a result, it was not possible to collect grazing data on the plot of rape and turnips. The plot sown with the cereal-ryegrass mixture in centre B, had also to be discarded because of rabbit damage.

In addition to suffering from competition from weeds, both the rape and thousandhead kale seedlings suffered from flea beetle damage at Centre A. The plots at Centre B were sown late in July, 1949, and then suffered a prolonged period of dry weather. This resulted in an almost complete failure of the Italian ryegrass in all the plots, and also retarded the growth of the brassicas. The lack of weeds at this centre was due to the plots being sown on reclaimed nardus-fescue land. The plots at Centre C made good growth throughout the summer, and were the most uniform when the lambs were turned on them.

Table 1

Average Percentage of Each Constituent in the Sample

Mixture	Constituent	Percentage		
		Centre A	Centre B	Centre C
Mixture 1	Winter rye	41.8		54.0
	Italian ryegrass ..	51.3		41.6
	Other grasses and weeds	6.9		4.4
Mixture 2	Rape	24.2	99.5	61.3
	Italian ryegrass ..	55.1	0.5	29.0
	Other grasses and weeds	20.7		9.7
Mixture 3	Thousandhead kale ..	16.8	99.0	36.9
	Italian ryegrass ..	67.2	0.5	54.0
	Other grasses and weeds	16.0	0.5	9.1
Mixture 4	Rape		43.3	42.6
	Hardy green turnips ..		56.7	45.9
	Other grasses and weeds			11.5

Utilization of the Crops

Wether lambs of the Welsh Mountain breed were used to graze all the plots. At Centres A and B they were home-bred. It was necessary to select lambs from two flocks for Centre C, but both flocks were similar in type, and the same number from each grazed all the plots. There was an appreciable variation in the individual weight of the lambs. After weighing, the mean weights were calculated, and the lambs were then divided so that those of approximately equal weights grazed each plot. The average weight of the lambs showed a very small variation. All the lambs were fasted indoors for a period of 14 hours before each weighing. This procedure was followed at all centres.

Table 2

Dates of Sowing and Grazing

Centre	Date of Sowing	Date Grazing Commenced	Date of Completion of Grazing
A	June 23, 1948	September 7, 1948	October 16, 1948
B	July 22, 1949	October 21, 1949	December 10, 1949
C	June 2, 1949	August 12, 1949	October 4, 1949

The live weights of the lambs and the gains made on each mixture are presented in Table 3.

Table 3

Weights of Lambs Grazing Forage Mixtures

	Average Live Weights in lb.		
	Centre A	Centre B	Centre C
Mixture 1—			
Initial weight	53.5		51.4
Weight on completion of grazing	58.1		58.7
Liveweight increase per head ..	4.6		7.3
Liveweight increase per acre ..	67.4		122.0
Mixture 2—			
Initial weight	55.9	54.2	51.5
Weight on completion of grazing	63.0	60.1	63.8
Liveweight increase per head ..	7.1	5.9	12.3
Liveweight increase per acre ..	77.3	52.0	205.0
Mixture 3—			
Initial weight	53.3	51.5	51.4
Weight on completion of grazing	62.6	56.5	63.5
Liveweight increase per head ..	9.3	5.0	12.1
Liveweight increase per acre ..	87.3	57.0	203.0
Mixture 4—			
Initial weight		57.4	51.4
Weight on completion of grazing		61.7	62.8
Liveweight increase per head ..		4.3	11.8
Liveweight increase per acre ..		43.0	197.0

Conclusions

The date of commencement of grazing varied from centre to centre, due to different sowing dates, but grazing of all plots at the same centre commenced simultaneously. Thus, the mixture of rye and Italian ryegrass was at a disadvantage, as the former ran into head between six and seven weeks after sowing. If this mixture is sown about mid-summer, it is desirable that grazing should commence within five weeks of the sowing date, as much of the feeding value of the rye plant is lost when it reaches the heading stage. When the mixture is sown from the end of July onward, then the risk of heading in rye is much reduced. The fact that so many plants had reached heading stage at Centres A and C is reflected in the lower liveweight gains made by the lambs grazing these plots. All the lambs were weighed about the middle of the grazing period. The lambs grazing the rye-ryegrass mixtures made a greater liveweight gain during the first month than those on the other plots. The former made little or no liveweight gain during the last fortnight or so when the rye was in head.

The lambs did not show any particular preference for the individual constituents included in mixtures 1 and 4, but in the case of the kale-ryegrass plots they grazed the Italian ryegrass in preference to the kale. In Centre B, when there was an almost pure kale crop, the farmer considered that the lambs had decreased in weight after being on it for 10 days. It was necessary to complete the grazing of all plots at any one centre on the same day. The rape-ryegrass plot at Centre A, and kale-ryegrass plot at Centre B, were not grazed bare and could have kept the lambs for another 10 days.

Practically all the lambs were graded direct from the plots, and they were stated to have killed out satisfactorily. On an acreage basis, or even on liveweight increase per week, only the mixtures at Centre C gave reasonable returns. At present prices 200 lb. liveweight increase, or say 100 lb. dead weight at 2s. 3d. per lb. (September, 1950) gives a return of £11 5s. per acre. This is considered satisfactory for pioneer crops on such land. Then there is the improved fertility of the soil, and, with the ryegrass mixtures, the possibility of additional valuable grazing during the following spring. At both Centres A and C, the Italian ryegrass provided keep towards the end of March and early April during a very lean period for ewes and lambs. Although accurate figures are not available, this keep maintained a large proportion of the flocks, thus enabling other leys on the holdings to make good growth before they were grazed.

The mixtures at Centres A and B did not give adequate returns for two reasons : (1) The brassica plants had not made sufficient growth—an additional nitrogenous top dressing would have been worthwhile ; (2) Grazing commenced too late at Centre B, and wet weather during November mitigated against the lambs making satisfactory progress.

In the above experiments the lambs were confined to one plot during the grazing period. This is open to criticism. Many flock-masters hold the view that better utilization of pioneer crops is achieved when lambs

grazing them are given access to an adjoining stubble, or an old pasture. This practice warrants critical scientific investigation.

Time of grazing is another important practical consideration. Under the present price structure, that of fat lambs falls during September and most of October, is static throughout November, and begins to rise again in early December. There is a tendency on many farms to delay the grazing of green crops, so that the lambs can be kept until the end of the year. This may be sound practice under favourable conditions, but in the higher rainfall areas of Wales it is doubtful whether lambs increase, or even maintain their weights, towards the end of the year. There is a belief among sheep farmers that crops of rape, or rape and turnips, which show no visual differences, vary appreciably in their fattening capacity on upland and lowland farms. There is probably a lot of truth in this, but it is a very complex problem to investigate, as weather conditions must play an important role in the utilization of these crops.

Now that our marginal and hill areas are in the forefront of the agricultural industry, there is need for more critical investigation of some of the problems that face farmers on such land. The production and utilization of green crops is only one aspect, but the pilot experiments described above indicate that here is a field that calls for scientific investigation. All the information obtained would be most valuable to farmers who often have to labour under difficulties.

The writer is grateful to the farmers who co-operated in carrying out these experiments, and also to D. T. Evans and I. W. Jones, of the N.A.A.S. staff in Carmarthen and Merioneth respectively, for supervising the field work.

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